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ABSTRACT

These 16 papers presented at the 1979 conference of the International Simulation and Gaming Association focus on new simulation and gaming models and research findings, with an additional emphasis on the use of simulation and gaming techniques for analytical as well as communicative purposes. Specific topics covered include (1) the state of simulation/gaming in the Netherlands, (2) the design and application of simulations and/or games, and (3) simulation/gaming as a research tool. Nineteen references are included. (See Volume II for more papers from the conference.) (BK)

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HOW TO BUILD A SIMULATION/GAME

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PREFACE

From 8 to 11 August 1979 the 10th conference of the International Simulation And Gaming Association, ISAGA, was held in Leeuwarden, the Netherlands. Organizing institutions were Sociaal Hoger Onderwijs Friesland and Teacher Training Institute Ubbo Emmius. During these four days the 160 participants from 11 different countries occupied themselves theoretically and practically with the central theme of the conference: "how to build a simulation/game?".

ISAGA has existed as an association for ten years and constitutes an international platform for those who, often from different viewpoints, occupy themselves with simulation and gaming activities. Members of the association come mainly from the U.S.A., Great Britain, W-Germany and the Netherlands, but there are also ISAGA members in e.g. the Soviet Union, Poland and Ghana. Under the auspices of ISAGA a conference is organized every year, the main goal of which is to have an informal exchange of experiences, and a presentation of new models and research findings. In addition the conferences are aimed at the use of simulation and gaming techniques for analytical as well as communicative purposes. Four times a year the contact between the ISAGA members is maintained by means of the ISAGA Newsletter. The general secretariat is in the hands of Prof. Dr. Jan H.G. Klabbers at Nijmegen University, the Netherlands.

In accordance with the nature and function of the organizing institutions an important part of the program of the conference in Leeuwarden was focused on the application of simulation/gaming in education and training. Besides, the organizers of the Leeuwarden conference hoped to facilitate the contact between users and producers.
The conference was aimed at two target of teacher delegates:

those who are interested but little experienced in simulation and games, and those who apply gaming in their lessons and are interested in (new) forms and methods.
As to the education and training centred contributions the aim was a great number of different subjects and forms of gaming.

Besides contributions geared to the needs of teachers the conference featured a variety of topics for participants from the field of science, planning and policy-making.

In order to be able to compose a balanced program, we divided the conference theme into a number of aspects that could be a point of application for theoretical extension and practical elaboration. Specialists in the different domains were invited to deliver specific contributions.

The fifty promised contributions, which included lectures, demonstrations and participation sessions, could be divided into into the following categories:
1) general, centralized round the conference theme, 2) education, 3) political decision-making, 4) management training, 5) energy problems, and 6) medical applications. The chapters in these two volumes follow the conference categories to a certain extent, although new main categories have been introduced after the conference. These new main categories are:
- simulation/gaming : the design process
- simulation/gaming as a research tool
- simulation/gaming in education and training (in social sciences, technical and management training, medical training, urban planning; science education, language teaching and art education)
- simulation/gaming and policy making.

Every day the program started with a central introduction, after which the delegates could make their choice out of five to six parallel sessions. The first two days of the conference the theme was dealt with in introductions and in a more fundamental way. On the third day applications of simulations and games in education had a central place. Teachers from schools in the surroundings of Leeuwarden were given the opportunity to attend the conference. Besides, on that day two workshops were organized, in which the conference theme could be dealt with practically. The last day of the conference was reserved for a report on new technological developments (such as microprocessors, viewdata) and the possibilities for the application of simulation techniques, that result from those developments. An exhibition of literature and simulation/gaming materials was arranged during the conference.

From the nature of the program as described above it follows, that no delegate could attent all the sessions and thereby develop a general view of the conference. Therefore the organizing committee decided to bring together and publish all the written papers in this conference book.

Leeuwarden 1980 The editors.

Chapter 1:

Opening addresses.

1.1. Professor dr. J. Th. Snijders, Professor of Psychology of the State University of Groningen. Dean of Sociaal Hoger Onderwijs Friesland, Leeuwarden, The Netherlands. Member Steering Committee.

Opening address.

Ladies and gentlemen, guests and participants, I bid you all a most cordial and respectful welcome at the opening of the Tenth International Simulation and Gaming Conference.
At a meeting like this the audience is composed of two rather different parts. One part is formed by the initiates, the members of ISAGA and other participants in the conference. The second part consists of the laymen: official guests, associates, journalists, etc. You all are sitting here quietly side by side, but the thoughts and even the perceptions of the two groups among you are very different. For the insiders, the fact and the theme of the conference are self-evident and need no comment. The only point perhaps that asks for an explanation is why it is held in Leeuwarden.
For the second group, however, the theme of the conference is rather obscure and perhaps even somewhat peculiar. This was demonstrated by a journalist who telephoned me for information about the conference. One of his questions was: "Simulation, is that not a strange subject for a scientific association and for an international conference?"

I tried to explain to him why it is not. But I am not sure whether I was very successful. I think that was not simply the case of a journalist trying to be difficult, but that his question expresses a general feeling of reserve amongst the non-initiates towards the theme of the conference which is so self-evident for the members. A clear matter of split consciousness in the audience.

I consider it my task to seek a remedy for that uneasy state. To that purpose I shall try to explain that Simulation and Gaming is not a strange, but a very normal subject and a legitimate method for science, important enough to justify a conference and even to found a permanent association for its study. For the sake of convenience and brevity I shall not use the double term "Simulation and Gaming" henceforth but speak only of simulation. I am sure that one of the other speakers this morning will discuss the distinction.

As a starting point I will show you that simulation is not strange, but rather familiar to any of us. We are somewhat reluctant to admit it, because of the unfavourable connotation which words like "simulate, simulator" have got. But taken in the primary sense of "behaving as if", simulation is one of the main constituents of daily life, indispensable admixture to the strong somewhat poisonous liquor of reality. The employee behaves as if he were director and the director as if he were twenty years younger than he really is. Simulation already starts very early in human life. Take the baby crying extra loud as if in unbearable distress, only to command its mother's attention. Or take the fantasy play which begins to flourish in the second year. Some days ago I saw my little granddaughter busy with an old painter's brush pretending that she was painting a wall. But she did it with a strange, awkward poise which at first I did not understand. Then I saw it: she was pretending to be carrying a pot of paint in her left hand in which she now and again dipped her brush.

Each of you could add other examples of make believe, as you perform them every day. I still want to point out that simulation in ordinary life serves two different and as to some extent contrary purposes. On the one hand it is used to make things more complicated and thereby more interesting. On the other hand to make them simpler and thereby more manageable to our intentions. The former is the case in the abovementioned fantasy play and in creative activities. The latter, simulation as simplification, is the general way of learning. We will come back to this presently.

So far we have limited ourselves to the spontaneous, simple forms of simulation. But, as people always bring system into their madness, we have also systematized simulation. A great part of what we call culture consists in fact of systems of make believe. Take e.g. all the bows and phrases of etiquette, all the rules and customs of games, The first example which nearly always turns up in this context is the war-game in its various forms: the fighting dances of foreign cultures, the tournaments of the Middle Ages, in which real battle fighting was reduced to more manageable forms within a strict system of rules and showmanship. Or take the chess game which is really war reduced to the fighting of puppets on a piece of board. For the princes who played chess it served the dual purpose indicated above: a simplified imitation of real war and an interesting pastime for the dull periods without war. Besides war one of the most important fields of cultural simulation is education. In many cultures, primitive as well as modern, education includes various forms of behaving as if you were an adult. It starts with the girl playing she is a mother and ends with the student in the hospital acting as if she were a trained nurse. And here also the two aims of simulation are served. Reality is simplified in order to adapt it to the learning abilities of the young. And reality is imitated to make learning more lifelike and interesting than studying books. We have seen that simulation, behaving as if, is an omnipresent phenomenon in ordinary life and in the systems of culture. Let us now proceed to simulation in science. Here again we will make a distinction between several levels in which simulation functions in scientific activities. The first level is still a very general one, which borders on the above-mentioned cultural gaming. "The game of science" has become a popular expression. It indicates that science is executed according to a set of rules and standards, which have some similarity to those of sports and other games. This analogy, although real, is still rather superficial. A much more penetrating observation is that science as such is an endeavour to simulate nature. The main aim of science is to construct a substitute for reality which can be better analysed and managed. The efforts and also the joy of imitating nature pervade the biografies of great men of science. In a more specific sense simulation forms part of the experiment as a method of science. An experiment is essentially constructed as a hypothetical imitation of nature: let us act as if nature were like this and await what happens. Moreover, the experimenter often consciously plays a simulator's role; especially in experiments with people, in which he has to hide his real intentions from the subject in order not to influence his reaction. And this special feature of simulation is still intensified in psychology, where the subject sometimes is not only kept ignorant by the experimenter but directly led astray. I shall give as an example the classic experiment of Asch on group influence. The experiment is introduced as if it were a test of the ability to judge the length of lines. Pairs of lines are presented on cardboards to a group of experimental subjects. The question is posed for each pair of lines: Which line is the longest? Each subject has to answer in his turn, but all of them except one are accomplices of the experimenter (so-called 'stooges').

They have all been instructed to give the same false or wrong answer to some of the pairs of lines. For instance on the third card which is presented they all call the shorter line longer.

What will the only uninformed subject, who is the last to answer, do? I can tell you that it is a dramatic experience to see one subject stick to his own perception and another yield to the opinion of the group.

This is a clear cut case of conscious simulation in science. However it still has a subordinate character. Simulation is used here as an auxiliary technique to make the experiment possible. It is so to speak an accessory to science, not a regular method of science.

This last accomplishment, the development of simulation into a systematic method of scientific investigation, is a rather recent performance of a number of scientists, many of whom are members of the ISAGA. Some of them we have the honour of meeting in this hall today.

It may be that the difference between simulation as an auxiliary technique and as an independent scientific method, does not impress the outsider as being very big. I shall try to illustrate its importance by comparing it with the origin of experimental method in the 17th century. Since the time of the Greeks experiments had sometimes been performed, but they had had no clear function and no place of their own in scientific methodology. In the 17th century however the new scientists and among them especially Gallilei conceived a new way of thinking about nature, in which the experiment developed from an accessory technique into a central method, an according to some people the only proper method of science.

I think that nowadays we witness a comparable development of simulation from a secondary to a primary place in science, a method in its own right beside observation and experiment. And the conference which we are priviliged to open today is a step forward in this important development.

Dear listeners. I must resist the temptation to elaborate on other interesting points; for instance the way in which the development of scientific simulation influences the role of

gaming in education. But perhaps I have concentrated too long already on the laymen among you in an endeavour to reduce their mental distance from the conference theme. What I have tried to convey can be resumed in one sentence: simulation, which is a regular part of life and culture, is now developing rapidly into a regular method of science.
I feel obliged now to direct the attention to the other group in this room: the participants from abroad who, I think, want a short introduction not to the theme but to the place where the conference is held. As the programme mentions the conference is organized by two cooperating institutes: Ubbo Emmius and Sociaal Hoger Onderwijs Friesland. Both of them are newcomers in the field. For a better understanding of their position it is necessary to know something about the history of higher education in this part of the country.

The province of Friesland, of which Leeuwarden is the capital, had its own university till ± 1800. It was closed by Napoleon and not reopened after the end of the French occupation. Friesland has since got several institutes of what we call hoger beroepsonderwijs, Higher Vocational Training, but the efforts to regain a university have until recently been unsuccessful. In the last ten years however a cooperation with the university of Groningen has brought back to Friesland the beginning of a university development.
I shall not bore you with all the details. Some people might perhaps say that we simulate a university, but you know by now that simulation and reality are not necessarily a contradiction. In fact Ubbo Emmius is a Teacher Training College which is associated to Groningen university. And Sociaal Hoger Onderwijs Friesland (SHF) is a combination of a school for social work and a social science department of the same university. Further developments are pursued, but times are rather unfavorable for expansion in the university field, in this country the same as elsewhere.

Ladies and gentlemen. It was my intention to build a bridge between the two parts of the audience in this hall. On that bridge I have taken you before the gate which gives entrance to the domain of scientific simulation. Others will be your guides into that domain, but it is my privilege to open the gate. That is what I shall do now with sincere thanks to all who have prepared this moment and with the best wishes of success to the participants of the congress and especially to the members of the International Association.
I herewith open the tenth Simulation and Gaming conference.

1.2 Professor dr. H. A. Becker, Sociological Institute State University of Utrecht, The Netherlands. Member Steering Committee ISAGA.

The emergence of Simulation / Gaming.

1 Introduction

In 1938 the Dutch historian Johan Huizinga published Homo Ludens, an essay on the play-element of culture. It was not the first time that he wrestled with this subject, because since 1903 it appears regularly in his writings. The book has been reprinted in the Netherlands a number of times, and it has been translated into English, French, German, Portuguese, Hungarian, Swedish, Finnish and Hebrew (1). Huizinga defines play as "... a free act, not meant seriously, committed consciously and outside of normal life, nevertheless capable of involving the player completely, without material gain, taking place within a stipulated time-span and area, according to rules, evoking strong human relationships and preferably surrounding itself with secrets and disguises and other ways to accentuate its distance towards everyday life"(2). This definition characterizes his way of writing. There is a certain ambiguity and tension in his style, and thereby he forces his reader to re-think the subject. Huizinga also uses a second definition of play. Now it means "culture", or "...restrainment, not considering your own importance to be the highest and ultimate yardstick, but keeping within boundaries accepted of your own free will" (3). The second definition implies the first one, but not completely. There is a kind of "play" that is highly uncivilized and highly unrestrained. Huizinga calls it "puerile" (4). He sees traits of it in the Germany of his days, for instance.

In his book Huizinga surveys the romping of children and of young animals, the ongoings in law-courts, war, sports, philosophy and the arts. Each time he ponders to which extent the activities involved are playful or serious, civilized or barbarian. He has been the first to point out in a systematic way that elements of play exist in almost all parts of animal life and human society. The future of playing and therefore the future of our civilization fills Huizinga with gloom. In 1938 the waning of his world seemed inevitable to him. He died in 1945.

Homo Ludens is a contribution to the filosophy of culture and to the science of history. Huizinga would be surprised to hear that the book has become a contribution to the social sciences as well. If we look at the Social Science Citation Index, we find 125 references between 1969 and 1977 (5).

This publication by a refined, reputable professor of the equally refined University of Leyden became an evergreen even amongst games-folk, simulationists and similar strange birds. We find the book cited by Boocock and Schild (1968) in Simulation Games in Learning, by Preteceille (1973) in Jeux Modèles et Simulations, Critique des Jeux Urbains and by Harbordt (1974) in Computersimulation in den Sozialwissenschaften, to mention just a few examples.

The essay by Huizinga may be considered to be the first "theory of gaming". I shall take this book as a starting point for a short look at the development of simulation and gaming as fields of pure and applied social science (6).

With regard to definitions I can be brief. As soon as we put the terms "simulation" and "gaming" side by side, they specify eachother. In this case "simulation" becomes a connotation for analytical models and "games" becomes a connotation for communicative, educational, therapeutic and heuristic models. Elsewhere the terminology has been dealt with in detail (7).

2 Simulations as analytical models

The history of simulations has close connections with the history of the general systems approach that was conceived in the late thirties of our century. The systems approach within the social sciences owes much to Tinbergen (1939) in Statistical Testing of Business Cycle Theories, related to his work on national accounts commissioned by the League of Nations.

The late thirties have been a seminal period especially in the United States. At the Massachusetts Institute of Technology an approach was developed to understand the dynamics of complex systems. The foundation was laid in the 1930's when Vannevar Bush built his differential analyser to solve the equations of certain simple engineering problems. Such a set of equations is a model of the system it represents. The model describes the rules that govern the system behavior. The differential analyser, set up in accordance with the equations that are the instructions, becomes a simulator to trace the dynamic behavior of the system being studied. In the same period Norbert Wiener developed his concepts of feedback systems that were later given the name "cybernetics". His The Human Use of Human Beings lateron gives his views on cybernetics and society. Harold L. Hazen wrote some of the first introductory papers in the field of feedback control that was to be known as "servomechanism". In the 1940's Gordon S. Brown created the Servo-mechanisms Laboratory in which the feedback systems were expanded, recorded, taught and diffused. In the 1950's Jay W. Forrester was director of the Digital Computer Laboratory where digital computers were first used for systems simulators. Studies like Industrial Dynamics (1961), Principles of Systems (1968), Urban Dynamics (1969) and World Dynamics (1971) are steps in the direction of interdisciplinary, world-wide simulation models. The report to the Club of Rome by Dennis Meadows and his team, called "Limits to Growth" (1972), is an offspring of this family of models (8).

Vital to the growth of the systems approach was the publication of the Theory of Games and Economic Behaviour by Von Neumann and Morgenstern (1943). The theory of games is a mathematical model of rational decisionmaking. The results of the decision-making are dependent only on the decisions taken by human players, as a rule not more than two. A model built according to the theory of games is only remotely related to situations in real social life. Elements of the theory of games have been fruitful, however, as components of models that are more operational (9).

The history of simulation is closely related to the history of the computer. It was in 1937 that Howard H. Aiken of Harvard University set to work on an automatic calculating machine. He solicited the support of the International Business Machines Corporation and, in collaboration with them, built the Automatic Sequence Controlled Calculator, or Mark I as it is more commonly called. The first commercial computer (UNIVAC) entered the market in 1951 (10).

Most simulations are computer-simulations, but research is done also with the aid of man-computer-models and man-models. For instance Rome and Rome (1972), in a still undervalued experiment, mirrored a complex organization by instructing the computer to play the rank and file members and using human beings to represent top and middle management. They were interested in the way management coped with organizational tasks, and in the way it developed rules and procedures to avoid a breakdown of the system. By using both computersimulation and man-simulation the reliability of the results can be improved (11).

The number of simulation models has grown explosively (12). The same applies to the number of publications criticizing these models. Shubik and Brewer (1972) conclude: "Machine simulation has been oversold in the last ten years or so, and the shakedown is now taking place. The process is healthy, albeit painful in certain quarters" (13). This process is still going on, but at the same time important improvements are being made.

The first improvement lies in working with an explicit distinction between conceptual simulation-models and empirically based simulation-models. The conceptual models are rich in scope and theory but cannot be tested directly by predictions. The empirically based models stay on an operational level and can be put to a predictive test (14). In some fields of study both types of simulation models are available already and can be used in combination with eachother. For instance Mesarovič and Pestel (1974) with *Mankind at the Turning Point* on the one hand and Cohen (1975) with *Production, Manpower and Social Planning* on the other hand. The first is a world model, containing a lot of empirical data and theoretical ideas but nevertheless remaining a conceptual model. The second is a model of South Korea, modest enough to be tested by predictions. The ideal, of course, is a combination of one conceptual model and a large number of closely related empirical models. In the future a combination like this will become possible for world modelling also (15).

The second improvement concerns the empirical basis for simulation models. The need for over-time data-gathering is recognized more and more, and longitudinal data are becoming available in a lot of fields. The analysis of social and economic inequality in relationship with educational opportunities illustrates this development (for instance Boudon, 1973).

Simulation-models need a sound theoretical basis. The third major improvement is related to the development and application of techniques for constructing social theories (for instance Opp, 1970). The theories themselves must be conceived, compiled, tested and applied, of course, and much work remains to be done, but the road to the theories we need has been paved.

The fourth improvement lies in the methods for the evaluation of simulations. Making predictions (post-dictions in fact) has turned into a powerful instrument. Often the reliability and precision of the results of simulation turn out to be relatively low. The vital point is the assessment of the degree of predictability of processes in social systems. If a low degree of predictability is found by repeated measurement, the result of the analysis is worth while for policy-makers and scientists alike. If a model has been tested by predictions and has been able to hold its ground during this attempt at falsification, it has earned a high credibility in the eyes of outsiders and specialists.

The fifth improvement changes the frustrating situation that the results of large numbers of simulations are never applied by policy-makers or other potential users. Bolden (1970) has involved policy-makers in designing small-scale models or modules themselves and thereby enhances their willingness to use the results of the full-scale simulations. Interactive simulation and man-gaming have been applied with success also. More techniques are still badly needed, however.

Simulation models have become a powerful instrument in the field of policy-analysis. Often they are used to provide policy-makers or the public in general with forecasts of coming events. This is an important application of simulation, but the relatively limited possibilities for reliable and precise forecasts hamper the growth of these activities. Recently an approach is gaining field that has a more modest aim. In an "analysis of consequences", called also "assessment of impact" or "ex-ante evaluation", the most likely effects and side-effects of future policy-activities are approximated. This enables policy-makers to do a lot of debugging prior to action in real life. Recent examples are provided by the report on applications of the UNESCO Educational Simulation Model dealing with Rwanda, Chile, the Philippines and Nepal (1977).

Simulations models have contributed to the enhancement of the body of knowledge of the social sciences as well. Lindenberg (1971) provides examples of this development.

3 Games as communicative models

In the history of gaming the year 1943 is a peculiar milestone. In that year Herman Hesse published The Glass Bead Game, a novel about an imaginary country somewhere beyond the year 2,000. In Castalia the ruling elite plays a game that is a synthesis of music, arithmetic, poetry and astrology. The glass beads are part of an abacus, a calculating frame. The analogy with a computer has been pointed out quite often. The way in which the refined participants in the glass bead game compose their plays and stage their demonstrations bears a lot of resemblance to the cult of system analysts and information science experts in our times delicately handling their elegant models, calling a computer "she" and treating her as a lady of the nineteenth century. The novel by Hesse tells us about the initiation of Joseph Knecht into the office of Magister Ludi, his years as "high priest" and finally his abdication, exile and death while trying to keep up with a young Castalian swimming across a mountain lake. The story hidden behind the tale is the decline of Europe after turning into a too sophisticated society. Hesse got the Nobel Price in literature for this book. In a way this novel is as much a piece of pure science as it is a piece of literature. It is a pity that Huizinga has not been able to read it and incorporate it in his Homo Ludens. Two doomsday philosophers using games to explicate their thoughts.

The history of gaming is to a large extent the history of war-games. The best illustration of this is The History of Chess as documented by Wood (1972). For a long time wargaming has drawn little attention outside the military world. Huizinga, for instance, does not even mention wargaming in Homo Ludens. Pearl Harbour has changed this situation drastically. As soon as it turned out that the games played at the Total War Research Institute and the Naval War College of Japan had contributed vitally to the success of the surprise attack on the American fleet on December 7, 1941, these exercises where imitated elsewhere on a large scale. During and since the second world war military gaming has flourished. Other fields adopted these techniques also. The American Management Association developed the first widely used management game in 1956 after its members visited the Naval War College (Raser 1969). Nowadays almost every activity in society has its games (Horn 1977). The computer was brought into gaming during the fifties. Interactive simulation taught human players to govern countries, cities, business firms and universities. In the seventies man-gaming somehow won from man-computer-simulation, at least in numbers. The causes for this development are not yet completely clear. One explanation is, that computer programming is still a very time consuming activity. Another explanation is, that it is still relatively difficult to read computer output. Both handicaps do not look final. May-be man-computer simulation will gain in number in the future.

A lot of problems in contemporary society are problems of communication. They require the formulation, transmission and understanding of ideas and the adjustment to new ideas after having evaluated them. Gaming, The Future's Language, can provide us with ways and means to overcome this communication problem, Duke (1974) has assured us. I shall give an example of a recently formulated problem in communication. At the International Institute of Applied Systems Research at Laxenburg in Austria, Dobrov, Randolph and Rauch

(1979) have elaborated new communication techniques for international team research. They state that "Complex global problems can only be solved by comprehensive and global means - such as those which international team research offers. ITR should also be expected to have strong feedbacks into each nation's own scientific effort, because of the very international character of this form; scientists from different nations will learn the ideas and methods of other regions and will personally be confronted with the most advanced means of scientific organization and communication". These networks for scientific communication up to now only include direct, unstructured communication. It is obvious that the next step will have to be the application of frame games to intensify the processes of creativity and communication involved.

Education and training are specific kinds of communication. Educational research has shown that inductive approaches are superior, although only slightly, to deductive approaches. Gaming is excellently suited for inductive teaching and training, allowing for a deductive input in later stages of the communication process. Educators are critical individuals. They want to experience new approaches themselves before applying them in the classroom and they want to experiment with them. This has lead to the inclusion of gaming in the education of teachers, in the United States and elsewhere, for instance in the Netherlands at Ubbo Emmius, Leeuwarden.

Gaming has been used as a heuristic device since the early days of war gaming. A recent example outside the military field is given by the Washington Post on June 7, 1979. In an article on "Conrail Plays Games to Regain Profit" a game is described between the Consolidated Rail Corporation of Philadelphia, a rival railway company and a rival trucking firm. The battle of Conrail includes an analysis of the consequences of deregulation of the railway tariff-system. The report by the Washington Post mentions a gaming session held with government officials, bankers and planners. It actually gives an eyewitness account of a session in which newspaper reporters played the game. This implies that Conrail's game was not only used as a heuristic device but as a "modern-age lobbying formula" as well. The Washington Post mentions also that professor Dick Duke from the University of Michigan designed and staged the performance.

The step from heuristics to change agency and therapy is but a small one. I would like to concentrate our attention on a special field: the research of childrens' play and toys for visually, mentally, and physically handicapped children and for socially uprooted children. Van der Kooij and De Groot, both from the Institute for Special Education of the University of Groningen have reviewed the state of the art in That's All in the Game (1977). The young child under seven years of age spends the largest part of its waking hours at play. In general the number of hours for play is estimated at 15,000 per child during the first six years. Childrens play is studied to learn about socialization processes and the use and abuse of toys. The play of individual children is often used as a diagnostic and therapeutic aid. As far as I can see a collaboration between pedagogues specialized in young children on the one hand and simulationists and gamers on the other hand is still in its infancy.

A vital asset of gaming is its accessibility for comparative evaluation research. In most cases traditional ways of communication, education, training and the like can be compared with gaming. Allen (1970) has illustrated the virtues of nonsimulation games in this respect, but other kinds of gaming show these virtues as well.

Gaming can make a contribution to the body of knowledge of the social sciences as well, which illustrates, that the distinction between simulation and gaming is a relative and sometimes arbitrary one. The article by Greenblat (1972) on "Sociological Theory and the 'Multiple Reality' Game" proves this.

4 The futures of simulation and gaming

At first sight the collaboration between simulationists and games-folk looks a bit strange and temporary. The simulationists adore mathematics, research, computers, getting reliable and valid answers to unambigeously formulated questions and helping imaginary prisoners to solve dilemmas in order to get out of non-existing prisons. Those addicted to gaming like to create entities like "learning environments", put a lot of "gaminess" into their models, get a kick out of Lego and other toys and seem to be more interested in satisfying players than in rigid control of experimental conditions.

If we take a close look at developments during the last ten years outside and within ISAGA a different picture arises. Developing an analytical simulation model often starts with a preliminary model that is played with a number of knowledgeable people in order to get an impression about the most important positions and relationships, the strength of these relationships and the boundaries of the system involved. When the computer model is finished, quite often human players are engaged to serve as linking-centers between the submodels. This is far less time consuming than programming the interrelationships between sub-models in a formal way. As soon as policymakers have to use the results of the computer-simulation, man-games or interactive simulation are applied to give the policy-maker an insight into the potentialities and limitations of the model.

Gaming-people from their side realize that they must be able to prove the power of their model to communicate, to teach, to evoke new ideas and to mold attitudes. This forces them to evaluate the working of their models and to put them to a test under experimental conditions. This implies as a rule cooperation with simulationists or kindred research-specialists. In addition to this, more and more theories and research findings are incorporated into the art-science of designing, directing and evaluating games.

I do not forecast that all simulationists or all gamers will cooperate in the future. There will be a lot of lone wolves. But a large number of simulationists and a large number of gamers will consider it worth while to continue and improve this cooperation. ISAGA can play a vital role in this network of cooperation. During the last ten years, simulation and gaming have shown a lot of progress, but that progress has been rather slow. If we look at the tasks ahead of us, an extrapolation of the present growth-rate leads to a very unsatisfactory situation. The development of methods and techniques and their application to problems of a practical nature require other means.

An alternative future would offer a number of initiatives that can serve as pace-makers. I shall take the development in the Netherlands as an example.

At least one center for policy-analyses in the social sciences specialized in simulation and other techniques of applied systems analysis is badly needed. This center must be able to accept research-contracts from government agencies and other organizations. The center has to be given a close link with one or more departments in universites developing new theories and techniques for policy-analysis and providing post-graduate post-experience training.

With regard to gaming at least one national center must be available where potential users can learn to design or adapt their games, to practise directing games and to evaluate them. The Extension Service of the University of Michigan could serve as an example. At this moment Leeuwarden offers an appropriate basis for a development like this.

Looking at the European scen the IIASA in Laxenburg is an international center for techniques like simulation. The institutes specialized in research-projects on a contract-basis like Battelle Memorial in Geneva and Frankfurt provide opportunities for application.

Gaming in Europe is less fortunate. An English-speaking training center and documentation service does not exist. Capacity for development of new games on a contract basis is still very limited. In this respect, too, improvement of the situation is necessary.

5 The late thirties and the late seventies

The late thirties and the early forties of this century have been a period of tension, conflict and ultimately of world-wide war. The pessimism of Huizinga had a firm basis. At the same time those years have been a golden age for science. The tension and of course the war-efforts have led to this outburst of scientific creativity. Most of these scientific innovations took place in relative isolation, and only years later the possibilities of combining new findings were discovered. Huizinga died before he could overlook the scientific importance of the late thirties.

We are now in the late seventies. It is tempting to draw comparisons with the late thirties. Historical comparisons are tricky, however, and therefore we must be careful. If political and economic tension have a favourable influence on science, a new golden period might be expected. Thank heaven there are no large-scale wars at the moment, but for instance the energy shortage is serious enough to lead to high-pressure scientific research. Are we again in a golden period? It is too early yet to draw conclusions, but certainly a number of scientific innovations look highly promising. Applications in the field of DNA could change the food situation and human life itself. The microprocessors are triggering a revolution in human communication, and the vital role of that communication is undisputed.

Is gaming indeed a new language that fits into the communication of the future? Maybe, and we all hope so. Is simulation ready to turn policy-analysis into a reliable tool for preparing effective social policy activities? Perhaps, but it is too early yet to draw conclusions. In any case we can conclude that a lot of promising interrelationships between already existing new practical and scientific developments have not yet been explored to the full.

In the first place this ought to lead to the application of simulation and gaming in fields that need them. International team research is an example of this challenge. In the second place simulationists and games-folk ought to incorporate developments like the advance of the chips into their work. In the third place we will have to apply our techniques in fields that are ready for it. The CONRAIL-gaming might illustrate this point.

Notes

(1) J. Huizinga, 1938; also Verzamelde Werken, Vol. IX, Haarlem 1953.
(2) page 14.
(3) page 217.
(4) page 209.
(5) also in Arts and Humanities Citation Index 1978 (till August) 15 citations.
(6) see also H.A. Becker, 1979.
(7) documentation of ISAGA conference 1979 for instance.
(8) historical account: Forrester, 1971;
(9) examples of "Prisoners' Dilemma Game" can be found in Simulation and Games, number of volumes.
(10) Borko 1962.
(11) examples in Becker, 1976.
(12) overview of surveys in Becker, 1976.
(13) Rand analysis 1970 and 1971.
(14) Becker 1974.
(15) for instance project LINK may provide the data necessary for this development; see Becker, 1976.

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Chapter 2 :

State of the art in The Netherlands.

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Simulation /Gaming in the Netherlands 1969 - 1979.

Introduction

1 The first years

In 1969 in the Netherlands a number of publications appeared that constituted the beginning of systematic activities with regard to simulation and gaming. Boskma and Tromp reported about their all-man simulation of international relations. Valkenburgh presented in "Anatomy of Conflict" a model of a computer simulation dealing with human conflict. Kuipers simulated the collaboration between sea-going vessels. Steenbrink reported about the "Future Game" as a computer simulation of economic and social developments in The Netherlands. Becker simulated the succession of managers in the Netherlands between 1960 and 1980.

In 1969 communication between simulationists and games-folk in this country was almost non-existent. This changed somewhat in 1971, when the second international conference on simulation and gaming was held at the University of Utrecht. A lot of "first encounters" occured, but it is still astonishing to see, that often contacts remained restricted to incidental meetings at conferences abroad.

2 Computer-simulation

In the Netherlands computer-simulation has mainly been of the 'what, if..." type. Policy-measures by government and other organizations have been analyzed with regard to their past and their most likely consequences in the future. Albinski and Schute looked at the impact of restrictions on student enrolments, Cohen simulated the socio-economic development of Southern Korea, and the Central Planning Bureau assessed the impact of restrictions on academic curricula. A location model about the Eindhoven-region was developed by Veldhuisen and Kapoen. Vriesman from the policy analysis devision of the Delta Department (Rijkswaterstaat) developed a model regarding problems associated with the diking of a Dutch arm of the sea (Oosterschelde).

It is difficult to judge the impact of these and other computer-simulations on actual policy-making. Have politicians and government officials in the corridors of power been induced to listen to the results of the 'what, if..." studies? Maybe it takes a very long time to get heard in those corridors. A number of developments are favourable, however. Shortly an educational planning bureau will be created. Policy analysis in general is getting more attention and financial support.

3 Man-computer simulation

Interactive simulation, involving human players in a cooperation with a computer, has been developed at the University of Nymegen. Klabbers and his team have succeeded in creating models that can give policy-makers an opportunity to learn about the consequences of their decisions before these decisions are taken in real life. Ecological policy-making, decisions in re-

search management and in planning the dental profession have been covered by these models.
At several university Business Departments management games have been included in the curriculum.

4 Man-simulation

Gaming with human players has shown considerable growth since 1964.
At the University of Utrecht Peter Smit has come forward with urban and regional models showing those involved in urban and regional development the consequences of their activities and studying these activities at the same time.
For a number of years a "games club" on this subject has met regularly in Utrecht to practice the application of various models. At the same university Burie analyzed town-planning by re-enacting the stages of actual development involving players that have practical experience with the processes mirrored in the model. At the medical departments of the universities of Utrecht and Maastricht work has been done in the field of patient games. Introducing gaming into the field of education has been the main objective of Bruin and others at "Ubbo Emmius" in Leeuwarden.

MAN - SIMULATION : INTERNATIONAL RELATIONS

1 Developments

A few years after the Polemological Institute had been founded in Groningen 1962 the first simulation game took place. A rather simple affair in which participants were instructed to win, finally, a bottle with spiritual contents. Soon it became apparent that such external motivation was quite unnecessary as the game provides its own motivation. From the beginning these simulation exercises have been set up for educational purposes.

Later they have also been adapted for research purposes.

The subject matter of the simulation games was generally international relations. With the growth of a group of interested and enthousiastic students around the initiators Boskma and Tromp it became possible to adapt, develop, and try out the original model for more specific themes and educational purposes. Had originally a main theme been the international relationseffect of the introduction of technological innovations, especially the final introduction of nuclear weapons, later themes focussed on the following problems:
under-development, possibilities and oppurtunities of small countries in a world dominated by large ones, the origin and working of the European community, the functioning of the U.N. organisation in the world, and the role of nongovernmental groups in national decisionmaking.

2 The main model

These simulation games had in common a number of features which will be outlined following the rather typical model which received national coverage by the VARA-television corporation in 1969.
The world model contains two large and two small, and one intermediate country. Each was played by a separately roomed group of participants. According to the given instructions the group was divided into five subsections, each representing a relevant part of society: industry, the army, consumers, press, and a non-governmental opposition. Participants were asked to act according to what they considered the best for their own particular wishes, the stated purposes of their section, their perception of the needs of the country, or for the world at large. It would be their world in which they had to live during the simulation experiment.

Between the different countries a mixture of written communication, and face to face meetings, conferences were the only possibilities. The national press was required to produce a newspaper. A single sheet of paper to be distributed every playing period. To obtain news the press was in principle allowed to roam through the world, unless restricted by other governments or conference participants. The actual functioning of the press, whether they would bring objective news or try to influence people, was a decision left entirely to themselves.

Nevertheless they provided also a means of introducing events by the game director in case a simulation game proved difficult to start up.

The sections industry, army and consumers were expected to organise some kind of government. Usually this resulted in a government consisting of delegates from each section. This government was usually controlled by the other participants in a parliamentarylike fashion. Our intention was that participants would feel responsible for their own choices in this way. The government made each period a budget allocation in which the national income is spent on the upkeep of the production apparatus, national security, national wellbeing and consumption. According to a more or less complex economic model these allocations together with trade, aid and depreciation of the production apparatus determine the kind and size of the production apparatus of the next period and the size of the national income for the next period. In the more complex models efficiency coefficients were used which could be varied during the game. The variations were conditional upon the allocation and size ratios between the different parts of the production apparatus. E.g. increases on education, and thus supposedly on research and development would change the industrial efficiency coefficient. The size of the efficiency increment however depended in its turn on the ratio between the industrial and agricultural production, among other things. This economic model provided the dynamics behind the simulation game together with the time-structure which required that decisions were made at regular timepoints.

At the start of the simulation the written history and the economic parameters determine the kind of country. A large agricultural and a small industrial production apparatus being typical of a developing country for example. After some three years the start situation can be considered to have worn off in the sense that participants from then on are confronted with the results of only their own past policy. This confrontation provides in our opinion the strongest motivation in simulation gaming. It finally will end up in the questions to be asked after the simulation game proper is over:
"What were the participants' goals and measures of success?"

Debriefing after the game brings out the explicitly the educational purposes. During this discussion parallels with reality are drawn and the (supposed) shortcomings of the model and reasons for them are discussed. In view of this evaluation the validity of the simulation games for educational purposes is a rather subordinate problem. On the one hand agreement between small group processes in actual or simulation decision making is generally large enough for educational purposes in secondary schools and introductory university levels. On the other hand the parallels between these small group processes and processes on the international level are open to considerable doubt as we know hardly anything about the latter.

3 Research

Regarding research simulations Tromp (1976) has studied the effects of military versus pacifist attitude upon behavior un-

der stress and threat in simulation experiments using the outlined model. He was able to show that an intervening variable, connected with knowledge of and insight into a particular decision situation, in this case international relations, could extinguish the effects of attitudes.
A second research effort, with a version of the main model, has been carried out by Altena, who was interested in the perception of foreign policy by the ordinary citizen. His dissertation will appear this year.
Out of the educational simulation efforts a third research development grew, which focussed not on international relations, but on democratic decisionmaking. Boskma, van der Meer, and Schreuder-Peters, now connected with the Twente Technical University are studying the (im-)possibilities of democratic relations in factories.

MAN-SIMULATION : (SECONDARY) EDUCATION

1 History

Up to a few years ago the training of Dutch teachers in secondary education was a one-sided knowledge oriented matter. Moreover teacher training institutes were highly heterogeneous as a result of the Dutch educational system, which is divided into various subjects and schoollevels. In 1971 the new Teacher Training institutes were founded, and one can state that then a start was made with the professionalisation of the training of teachers in The Netherlands. Within that framework room has been created for the development of new methods of instruction, others than the traditional frontal teaching.

In the Netherlands simulation/gaming is relatively new and unknown in secondary education. In the first instance it was developed at universities, in social work and in the 3rd-World movements of the sixties. Besides, there were valuable contributions in the field of Dutch language teaching and in drama.

In recent years simulations and games have found a regular place in the programs of a number of Teacher Training Institutes. Various models were developed for a multitude of subjects, including translations and adaptations of American and British materials. Games were tried out and put into practice in teacher training institutes and in secondary schools. At regular workshops professors of the institutes trained their practical skills and theoretical knowledge in the field. One could state, without wronging others,that the main pace-makers were the Geographical Institute, University of Nijmegen, and Teacher Training Institute Ubbo Emmius in Leeuwarden.

2 Reality

If one wants to develop simulations and games for secondary education, one encounters a lot of different problems. Often cost and available rooms are an obstacle, but there are also more structural problems. How to start simulation/gaming in a schoolorganization that is based on 50-minute lessons, and where games are considered something "out-of-order", something that is only appropriate after schooltime?
How to explain to one's colleagues that the chaos they perceive, is an important learning situation? As a matter of fact the role of a succesful game leader is very different from the normal performance of a teacher. In games the role-expectations of a traditional teacher are hardly answered. In such a situation it is very difficult to endeavor the systematic development of simulations and games in the curriculum of the school. In addition there is in the Netherlands hardly any historically rooted philosophy of education, in which problem solving situations are central.

As a matter of course when developing simulation/gaming mate-

rials one can make use of the existing models in other countries (by way of handbooks, bibliographies), but then you meet with translation problems and culture specific propositions. The political system in America differs from that of the Netherlands; Holland is a flat country and road construction and town planning are adapted to that; our pupils learn a national history different from their colleagues in England.
These cultural distinctions have as a result, that one has to select carefully and has to spend much time and energy on the remodelling of existing material.

In the past years we have produced Dutch versions of the well-known simulation/games BAFABAFA, STARPOWER, THEY SHOOT MARBLES, DON'T THEY? and FRONTPAGE. These developments were facilitated by good contacts with the British and American associations and the literature.

3 The Future

If the objective is to realize a valuable function for simulation/games in education, one has to construct theories about the didactic behavior in such learning situations.
At Teacher Training Institute Ubbo Emmius we have developed theories about problem solving learning, in which we try to denominate a range of process and project oriented methods of instruction. At a later stage research will have to support this initial work. Finely the findings and experiences obtained in this way have to find its proper place in the post-graduate courses for teachers in secondary education.

MAN-COMPUTER SIMULATION : MANAGEMENT TRAINING

In the early 1970's business-games were incorporated by Balkestein in the training of mechanical engineers at the Eindhoven University of Technology, followed by Hulshof at the Twente

University of Technology, de Meulder at the post-graduate course of industrial management and Snoeijs in the training of production engineers, both at the Catholic University of Leuven. At the Wageningen University of agriculture the business-game was introduced by Kampfraath.
Games of this kind are also used at the University of Stuttgart (Germany) and Graz (Austria).
At the School for Organization and Management, University of Groningen Laseur and Van Oosten developed and used a slightly condensed version of the Uretskymodel of the New York University.

In all training programmes the business-game is incorporated in the 4th or 5th year.

The primary purpose of these business- or management games, is to give the students an introduction to a number of aspects of what in Eindhoven is called "Technical Management", such as:
- production planning and scheduling;
- financial policy;
- decisionmaking, based on analysis of gained results, sale-prognoses and common sense;
- cohesion of various factors as sale, costs and their influence on production planning, launching of sales instruments, inventory control.

These simulations are not isolated, but are placed in a larger program and their object is to support the lectures in which the various aspects of management are discussed.
Along with the accumulation of knowledge about the subjects mentioned above, the development of analytical skill and the design of models (forms, lists and graphs) belong to the objectives.
The competition element, which is built into all these games, will teach the participants to compete with each other by means of developing a strategy and will put them in a position to

exercise the aspects during several periods and to take decisions under time pressure.

MAN-COMPUTER SIMULATION : DIVERSE INTERACTIVE APPLICATIONS

1 Introduction

The Social Systems Research Group (SSRG) is an interdisciplinary team focussing on the study and analysis of social systems with special attention to the policy- and decision-making processes in order to improve long-range social planning (1).

Systems theory is applied for the description and analysis of social systems, and in general computer simulation models are developed and analysed. In most cases the study of a particular social system is carried out with the use of what is called "interactive simulation". This approach provides a framework for integrating different perspectives on social phenomena, thus facilitating interdisciplinary research.
Within this context SSRG is doing research in the following three areas:

1 Social Systems Science
Methodological aspects of analysis and synthesis of social systems are studied, especially from the point of view of planning and decisionmaking. Elementary decision-making processes are being described and formalised.

2 Method of interactive simulation
Effective man-computer communication is studied at a functional, procedural, and physical level. Results are integrated and applied in the design of particular set ups. Criteria for effective integration are derived from insight gained by the study of social systems science.

3 Applications of interactive simulation since 1974
3.1 Interactive Energy-Supply Planning

3.2 Interactive simulation of decision-making processes in a research department
3.3 Interactive simulation with a demographic model
3.4 Interactive simulation of Dutch Dental Health Care System.

2 What is interactive simulation?

Interactive simulation implies on-line and real-time human computer communication and cooperation during the simulation. It is used in different contexts. It is both an analytic tool (i.e. for a social system) and a communication tool of human users with a mathematical model. These users need not to be familiar with mathematical models, and/or computer programming. Interaction between man and computer proceeds in natural language taking into account the way human beings and computer can cooperate and communicate.
More and more interactive simulation is being embedded in gaming with more emphasis on interaction within and between groups during the simulation. Several organizational structures are tried out during subsequent simulation/games and the way they influence the overall behavior of the system involved.

3 Background

During the sixties and seventies mathematical modeling of large scale systems has progressed from its pioneering stage to a professional discipline. Many studies have been published dealing with industrial systems, urban systems, Health Care Systems, ecosystems and the global system. Most of these studies can be viewed as invitations to policy dialogues i.e., discussions about policy problems, causes, impacts and options related to current social problems. Work of the Sociale Systems Research Group (SSRG) fits in this main stream of research. SSRG attempts to integrate developments in the field of computer simulation and gaming in the method of interactive simu-

lation.
In this regard SSRG has invested considerable time and effort in developing the method of interactive simulation. Interactive simulation is an appropriate framework to study social systems, as it combines the analytical power of computer simulation, mainly concerned with quantitative aspects, with human judgement and intuition i.e. the qualitative aspects of social system. The theoretical work of SSRG is to a large extent based upon the work of M.D. Mesarovic (Theory of hierarchical systems); J.W. Forrester (System Dynamics) and R.D. Duke (Gaming: the future's language).

Interactive simulation is in the first place a learning tool on how to deal with complex social systems, on how to respond to anticipations about the future, to create better understanding about social problems. In this respect it fits well with the general idea of gaming-simulation; participants engage in policy dialogues.

FINAL REMARK

During the preparations of the ISAGA 1979 conference in Leeuwarden the lack of communication between the diverse simulation/gaming users became apparent. This article is partly ment as a first step to fill the gap. A second step to be taken during the conference will be the founding of a Dutch simulation/gaming association.

The texts of this paper have been provided (in order of appearance) by:

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Chapter 3:

Simulation/Gaming.

3.1 Drs. R. Duke, professor in the Department of Urban Planning, The University of Michigan, Ann Arbor, Michigan, USA.

Format for the game- logic or intuition?

In another paper delivered at this conference, I've put forth "nine" steps or game design. Alternatively, perhaps, it could have been called "Game Design Made Easy" or "Even You Can Build a Game!"

My nine steps are:
1. Develop written specifications for game design.
2. Develop a comprehensive schematic representation of the problem.
3. Select components of the problem to be gamed.
4. Plan the game with the Systems Component/Game Element Matrix.
5. Describe the content of each cell in writing.
6. Search your "Repertoire of Games" for ideas to represent each cell.
7. Build the game.
8. Game evaluation (against the criteria of Step 1).
9. Field use and modification.

Similar documents abound in the literature; every major gamer has solved this problem not once but several times, and my list of steps--simple instructions for "How To Do It"--is quite good (as are the lists of my colleagues). Nevertheless, my list of instructions resorts to magic with Step 7: "Now, go build the game!"

Of course, I'm prepared to defend my "nine steps" as being carefully thought through and useful. And, of course, I can describe in great length why the first six steps will almost automatically solve Step 7. But the simple, eloquent truth seems to be that no matter who describes the problem, sooner or later it boils down to "Go build the game", at which point the designer is forced to resort to his or her own intuition and/or to the format of some other game that might suggest itself from previous experience.

In reviewing past games that I've built and in talking with many other gamers about their various experiences in game design, I've not received much help on this point. They do often make one or more of these three comments:

1. "I just keep 'playing around' with it 'till it works".
2. "It just seemed like the same kind of problem as the 'X' game dealt with".
3. "I don't really know where I got the idea for the game--it just seemed to come out of the blue".

In each case, they were quite familiar with their client; their objectives; and the subject matter. In many cases, they had been quite methodical about their game-building activity. In all cases, they are hard-pressed to describe their reasons for selecting the game format which they finally chose.

In developing this paper, I decided to select several games that I've contracted for and completed in the recent past. These experiences all share the following criteria:

1. They were all developed for a paying client; the client knew what his/her "problem" was; and the client made the final judgment as to how well the exercise met his/her objectives.
2. All five games have dealt with serious real-world problems which involved complex subject matter.
3. All these exercises were developed from the philosophy of games as a mode of communication (as contrasted with a teaching tool, a "happening", etc.)[1]
4. Each of the exercises was developed in a disciplined sequence (see the "nine steps", above).
5. Each met the objectives of the client.

These five games have each used different formats (see Figure 1). They are each unique in their application and, to my knowledge, original in their design.

This paper will address the question. "Why were these particular formats used for these particular applications?". Here, in five iterations, is the answer:

FIGURE 1

FIVE GAMES--OBJECTIVES AND FORMAT

CLIENT	GAME	OBJECTIVE	FORMAT
1. CONRAIL	RAILROAD DEREGULATION GAME	To allow top management to evaluate the impact on CONRAIL of deregulation of the rail industry.	A rate-setting problem(s)-using form with a micro-processor back-up; wall graphics for "eyewash".
2. CHASE MANHATTEN BANK	THE MONTAUK EXERCISE	To allow C.M.B. executives to evaluate development strategies for the International Division in a 1985-1990 window.	A matrix game to establish a logical referent for voluminous data where each cell defines the next more detailed matrix.
3. UNESCO	HEX - THE HUMAN SETTLEMENT MANAGEMENT EXERCISE	To encourage conferees to "let down their hair" for a candid discussion of the problems of communication, horizontal and vertical, in national planning.	Three games, each part of a hexagonal pattern, on stilts. Interactions required, both vertically and horizontally.
4. FAO	SNUS--SIMULATED NUTRITION SYSTEM	To familiarize national planning teams of Third World countries with the impact of various policies, both manufacturing and non-manufacturing sectors, on national nutrition planning.	A large board (4' x 4') with movable chips representing a stylized flow chart of the processes involved.
5. JPL	GEOTHERMAL ENERGY GAME	To force an engineering team to design an "Executive Summary" of a lengthy technical report which was suitable for congressional review.	A large wheel (3' dia.) divided into many rings and sectors; scenarios of major options.

1 The conrail railroad deregulation game dealt with a policy question that represents national policy impacting on a major corporation. The situation is little short of desperate, with CONRAIL requiring an enormous public subsidy each year to survive. Energy concerns require that efficient transport be developed (and competition and the free enterprise system are the presumed answer); inflation fears are of great concern (will deregulation feed the flames?).

The management of CONRAIL wanted to develop a more complete understanding of deregulation (as it was shaping up in a particular legislative bill) to gain some perspective on the in-house options available if it came to pass and to convey their understanding to members of Congress, to their competitors, to the regulatory agencies, and to the public.

The subject matter is complex, technical, and "dry". The main "actors" have a serious interest in the subject. If any insight is to be gained, they must be pulled far enough away from their day-to-day interests so that they might distinguish the forest from the trees. The concept of the cone of abstraction becomes the guiding criteria.

In response to these observations, the game design team first tried to mimic a CONRAIL "war room" located in Philadelphia. This took the form of a railroad route map which underwent a series of simplifications. The original 4,000 + terminals became 7; the 1,000 + competing transport lines became 3; the 10,000 shipments became 11; and the 7 distinct freight cartypes evolved into 1. In turn, the process of rate setting became more central than these omitted details. The accounting system was relegated to a microprocessor; and the final exercises became very much like a "live" case study, with the arguments and processes of rate setting being highlighted after the technical detail had been presented in the original exercise.

2 The montauk exercise - Chase Manhatten Bank was concerned that its position in the international market remain competitive over the next decade. Toward that end, a major study had been undertaken to collect data from its various world markets about its present and possible future states. A meeting was planned for the presentation of these data to management, with the objective of consolidating the enormous data files into some meaningful and hopefully manageable propositions for management to respond to. The original plans to present the data as format on a live computer hook-up had to be abandoned--the volume was too overwhelming (several millions of discrete data items were available; a logical presentation would entail several thousand matrices, each of approximately 100 cells); and the data was too "soft" (much of it was speculation about some future condition) to permit rigorous quantitative manipulation. To make matters more difficult, there was only a month available in which to develop, test, and present the final game!

The answer was to develop a role-playing exercise with two major innovations: (1) specialists on the staff were to serve as "human computers" and give the best answers possible, based on the data available and their human judgment and (2) a series of nested matrices was employed as a very visible logical construct to keep the participants from becoming lost in the data. The resulting exercise permitted the participants to guide the discussion in any direction, while keeping a road map through the nested matrices. If a particular thrust was not successful, the format permitted a fresh beginning with relative ease.

3 Geothermal energy game - The jet propulsion laboratory has evolved into a major contract research group for the federal government. One of its contracts entailed an evaluation of Geothermal energy as a potential alternative to fossil fuels.

A major study of several years' duration was completed, except for one very important detail--the government required a brief (50-page) executive summary of the technical report (several thousand pages) expressed in terms which would be meaningful to Congress.

Several attempts to develop this document failed for two reasons: (1) it was always too long (none of the staff of engineers was willing to see his work eliminated from the final document; (2) it was always too technical (well-head pressures, pipe size, details of environmental impact, etc.; nothing about international energy prospects, major options available to Congress, etc.).

J.P.L. asked for a game to be used to organize a two-day conference to focus on the problem. The objective was to evolve an outline for the executive summary which would list the content of the final document and the length of each anticipated section. Only three weeks were available.

The design team developed a game with three components: (1) ten scenarios, each describing one of the major policy options available to Congress (e.g. develop a national corporation, leave development to private industry, etc.); (2) thirty role discriptions, one for each of the engineering teams and each describing a U.S. Congressman or Senator thought to be pivotal to the final decision; and (3) a wheel (conceptual map) which organized about 1,000 variables, technical and nontechnical, which were central to an understanding of the problem.

The staff was then asked to form ten teams of three each. Each team evaluated the conceptual maps from the standpoint of their respective roles and scenarios; their decisions were placed on the conceptual mapping wheel in color. The ten wheels were later consolidated into one large wheel. Each wheel had blank spaces to allow new items to be added.

The results, as you will suspect, were that the engineers, in the role of politicians, were disinterested in technical data and more interested in social, political, economic, and environmental data. With the marked "wheels" as a guide, they were able to construct and agree to an outline in one afternoon; the report was successfully completed soon after.

4 Snus: simulated Nutrition System - The Nutrition Division of the Food and Agricultural Organization of the United Nations has, as one of its objectives, the training of national planning teams of Third World nations concerned with nutrition at the level of national policy. This is a complex subject which involves the production, transport, marketing, and final distribution of agricultural products; completion of industrial products; and the various decisions in the public and private sector which affect the final flow of food to human beings. The primary objective of the training was to familiarize the participants with the totality of the process and to sensitize them to the impact on nutrition among the poor.

Preliminary discussion with the staff in Rome and with other nutrition experts suggested that the topic was complex; that agricultural and industrial processes had to be included; that a flow of goods was an essential characteristic; that policy actors and production actors had to be represented. Discussions further suggested that the best way to illustrate the process would be in a simulated hypothetical country.

My own explorations into a general theory of game design had suggested that games were of three types: (1) implicit, (2) explicit, and (3) integral. Of these, the third type lent itself best to areas of science because it required a deliberate representation or model to be constructed; it permitted the game to be evolved directly by interaction of the player and the model.

A flow chart was developed and approved by the client. This was converted into an actual board game where the participants would move physically through the logic of the flow chart. This was later blended with a map representing the geography of a small nation; and the result, SNUS, has been quite effective for its purpose.

5 HEX - The human settlement game - The Human Settlement Division of UNESCO holds conferences for the purpose of training mid-management public officials at various locations throughout the world. These focus on various human problems such as housing, education, public facilities, utilities, etc. The conferees speak a great variety of languages from conference to conference.

UNESCO sought to develop a game which could serve as introduction to these meetings, to serve as an icebreaker. Because these meetings were frequently attended by local, provincial, and regional officials, there was often an initial period where the participants were uncomfortable and less than candid in describing where they felt the problem lay (each level of government, of course, felt that some other level of government was responsible). Further discussions with U.N. staff and various experts suggested that the greatest concern was with management problems, particularly problems in vertical communication.

The result was the development of three games played simultaneously. They were placed on stilts, one above the other. Participants are told to solve the game on their own "level" and are left to discover in practice that this can only be done if all three games are solved simultaneously; this, in turn, requires vertical communication. The game begins quite quickly; and as it winds down, the critique leads into an in-depth discussion of the real-world problems of communication in the actual country where the game is being played.

These five examples attempt to suggest a process of game design which is in part: (1) adherence to discipline, (2) the development of a logic for each case, (3) a reference to a repertoire of techniques, (4) intuition and inspiration; and, finally, (5) luck. Nonetheless, the author believes that of all these factors adherence to discipline is the most important and effective. The others will follow.

Note

(1) Duke, R.D., Gaming, *The Future's Language*, Halsted Press, New York, 1974

3.2. Dr. Cathy S. Greenblat, professor in the Department of Sociology, Douglass College, Rutgers University, New Brunswick, New Yersey, USA.

Some reflections on group dynamics and game design.

When I first saw the theme for this year's ISAGA conference "How to design a Simulation Game", I immediately thought of attending, for game design is the area of my primary gaming interests these days. Hopes of attendance were accompanied by thoughts of making a presentation; after all, I mused, I have now designed a number of successful games, and thanks to years of working wich Dick Duke, I have done so fairly systematically and reflectively.
Surely I should be able to pass on some of the insights I have gained through these experiences.

Shortly thereafter I received an invitation from Dr. Bruin in behalf of the organizing committee, with a specific request that seemed to make the task of preparing a paper even easier. They suggested that I first summarize what I had written a number of years ago about the claims made for learning with simulations and the evidence (or lack of it) to support these claims. They then proposed that I indicate the implications of this for game design. It did not seem a difficult undertaking; after all, I was to review my own earlier writing, and take the material one step further.

But my initial optimism about the ease of the task was soon diminished. Although I had referred to the paper numbers of times, and still received letters and verbal statements from others about how helpful it was, I realized I had not really READ the paper for some time. And when I did, I started to see holes in the formulation I had presented and more problems in the way those concerned with the design, use and evaluation of gaming had examined the enterprise.

The first part of the original paper was based on a review of books, published and unpublished articles and monographs, newsletters, and advertisements from games' publishers. Implicit and explicit propositions found in these materials were extracted, and organized in six general categories:
- motivation and interest in the subject matter,
- cognitive learning,
- changes in the character of later course work,
- affective learning about the subject matter,
- general affective learning and
- changes in classroom structure and relations.

The claims were phrased in simple descriptive form: for example, "participation in simulation games generates greater interest in the topics simulated", but I noted that almost all had explicit or implicit counterparts which were comparative: for example, "participation in simulation games generated greater interest in the topics simulated; this increment in interest is larger than the increment with other modes of teaching". Due to space limitations, only the descriptive form was offered; the reader was urged to add the comparative form to each entry.

Since some of you are newly entering the gaming field, let me take the chance of boring those who are familiar with the original paper for a moment, and read the list.
It suggests all those things people thought might happen to students or other participants in games. Probably nobody thought all these would happen, but the list was surely suggestive of the degree of optimism among gamers.
If anything, it seemed too long, rather than incomplete, at the time I wrote it. (Greenblat, 1973)

1 Motivation and interest.

a. Participation in simulation games is itself interesting and involving.
b. Participation in simulation games increases interest in the topics simulated.
c. Participation in simulation games increases interest in the course in which the simulation is employed.
d. Participation in simulation games increases interest, enthusiasm, and commitment to learning in general.

2 Cognitive learning.

a. Participants in simulation games gain factual information.
b. Participants in simulation games acquire explicit referents for concepts used to describe human behavior; abstract concepts such as "organization", "power", "stratification" and "negotiation" take on concrete meaning.
c. Participants in simulation games learn procedural sequences. "The actors must, of course, learn the rules, comprehend the essential features of the environment, understand the implications of the alternatives open to them, and develop increasingly elaborate strategies. They must be taught to operate the simulated system, in this instance in the hope that they will acquire a better concept of the larger system through a highly concentrated experience" (Meier, 1967: 157).
d. Participants in simulation games learn general principles of the subject matter simulated (e.g., the need for social control, good communications, and long-range planning).

e. Simulation games provide simplified worlds from which students can stand back and understand the structure of the everyday, "real" world.
"Games seem to display in a simple way the structure of real-life situations. They cut us off from serious life situations. They cut us off from serious life by immersing us in a demonstration of its possibilities. We return to the world as gamesman, preparing to see what is structural about reality and ready to reduce life to its liveliest elements" (Goffman, 1961: 34).

f. Participants in simulation games gain in explicitness: "The capacity to identify consciously elements of a problem in an analytic or technical sense".

g. Participants in simulation games learn a systematic analytical approach.

h. Participants in simulation games learn better decision-making skills.

i. Participants in simulation games learn "winning strategies" in those situations simulated.

3 Changes in the character of later course work.

a. Participation in simulation games makes later work (e.g., lectures, reading) more meaningful.

b. Participation in simulation games leads students to more sophisticated and relevant inquiry, for discussion of the simulation leads to questions about real-world analogies.

c. Class discussions following a simulation will involve greater participation by class members, as they will have had a shared experience.

4 Affective learning re subject matter.

a. Participation in simulation games leads to changed perspectives and orientations (e.g., attitudes toward various public and world issues, attitudes toward the importance of collective versus individual action, attitudes toward deviant life styles).
b. Participation in simulation games leads to increased empathy for others (e.g., national decision makers, ghetto residents) and increased insight into the way the world is seen by them.
c. Participation in simulation games leads to increased insight into the predicaments, pressures, uncertainties, and moral and intellectual difficulties of others (e.g., decision makers, ghetto residents).

5 General affective learning.

a. Participants in simulation games gain increased self-awareness.
b. Participants in simulation games gain a greater sense of a personal efficacy and potency.

6 Changes in classroom structure and relations.

a. Use of simulation games promotes better student-teacher relations.
b. Use of simulation games leads students to perceive greater freedom to explore ideas.
c. Use of simulation games leads to students' becoming more autonomous, thus changing teacher-student relationships.
d. Use of simulation games leads to students perceiving teachers more positively.

e. Use of simulation games produces more relaxed natural exchange between students and teachers.
f. Use of simulation games leads to increased knowledge of other students (by students) and greater peer acceptance (Abt, 1970: 121).
g. Use of simulation games involves a diminishing of the teacher's role of judge and jury.
h. Use of simulation games leads to teachers perceiving students more positively.

At the time, the list itself constituted a major contribution to the field, for previously claims were scattered in various locations, and no one had offered a compendium of them, no less a full classification scheme. The paper continued with two further sections:
A review of the evidence and a lenghty dicussion of the methodological problems of games research. The major conclusion offered in the first of these sections was that there was very scanty data to support the claims that were offered. We knew more about some of the propositions than about others.
For example, there were no data regarding the third category - changes in the character of later course work - and none for the last - changes in classroom structure and relations. The best evidence was for increased motivation and interest, which seemed to improve due to participation. And there was some evidence on cognitive learning and on affective learning about the subject matter, such as the development of greater empathy. Anecdotal reports were abundant; 'hard data' were clearly lacking.

A number of methodological problems in evaluation were then noted. I recall the first version of the paper, which was very different from the one that was eventually published.

I had been appalled at the procedures employed in almost every study I had reviewed, and had written a scathing critique of each one and an explanation of why one should be skeptical of the conclusions of even those few studies that existed. Before submitting it I showed it to an older, more experienced colleague in the Sociology Department at Rutgers. He urged me to tone it down.
"You are absolutely right in the content of your critiques", he argued. "But it is a new field, and if this is all the evaluation there is to date, that is said - but don't put too much of a damper on the efforts of those few people who are trying to get some hard data. They may be people you'll work with for years, and specific discussions of each paper may be ego-gratifying for you, but it will only make you enemies and perhaps hinder further preliminary efforts".

He was right, of course, and so I recast the criticisms into a general section on problems plaguing the researcher, and urgings for future study.

One of the critical problems I pointed out at that time concerned the failure to view students as individual, different learners. Student-players were considered a homogenous collection. And so I noted.

Finally, a general methodological shortcoming in the studies reviewed is the frequent lack of control for relevant student characteristics. In most instances, only scores for the total sample are reported. In many studies, such factors as sex of players and see balance of groups, social class background of participants, intelligence, school records, and pregame motivations of participants are not employed as independent variables to examine the differential effects of participation on students varying in these characteristics, although some researchers have found them to be important.

Robinson, (1966) controlled for cognitive style, need for dominance in analyzing his data; suchs factors are suggestive of the nature of further differentiations that might be made in attempts to ascertain who learns what from simulation (Greenblat, 1973: 280-281).

A few years later when Dick Duke and I collaborated on the writing of *Gaming-Simulation: Rationale, Design, and Applications*, we reprinted that paper with an update by Frank Rosenfeld (1975). The conceptual scheme still held up, and a bit of progress had been made in establishing that games were effective for some pedagogical goals.

But in a paper written for that volume, I expressed some new concerns (Greenblat, 1975). In a section on "Unanswered Question", I suggested we needed to pay attention to such issues as the potential *harm* of bad simulations, the potential *harms* of bad games, to students who don't like and don't learn from games, to the effects of teacher or administrator inputs, to the timing of gaming experiences, and to the number of games used within a course. Some of these questions had not been raised in print before, and unfortunately, none had been adequately answered.

And again, I echoed concern about individual differences in learning, albeit in a slightly different form. In a section headed "How can we understand the asymmetrical learning experiences of students who participate in the same game?" I noted the following:

Discussions of the experience of being a player seem to treat participation as a constant factor. Yet in most gaming-simulations, students are cast in very different simulated roles (e.g., poor person, city administrator, clergymen, etc.) wiht different goals, constraints, resources, etc., attached to them.

By internal definition, then, the experiences are different, and it could be anticipated that the nature and extent of learning by those in different roles would differ. In good post-game discussions there is of course a sharing of experiences and perceptions, but it is unlikely that this vicarious experiencing can fully equalize the differential learning. Attention thus must be directed to understanding and dealing with asymmetrical learning from the same gaming-simulation. (Greenblat, 1975: 191).

And then I made what I think was an important point, which I immediately dropped, not knowing where to take it at that time:

The problem of differential learning is compounded when we consider that the participant is really in three simultaneous roles: in addition to playing the simulated role, students are players in a game and students in a class. Those writing about games often ignore the latter two or assume that they are of no importance. Yet either of these may be dominant at any particular time and may seriously affect the learning that transpires. Add to this the effects of peer pressure, and the complications in understanding what is happening are magnified further.
Teachers and researchers can ill afford to ignore the "treble role" of players and must try to understand the factors contributing to dominance of one or the other at any given time. (Greenblat, 1975: 191-192).

Some of you are probably hoping (and I wish it were true) that today I am going to go back to these points:
- the evidence in general support of the claims and the problem of failure to look at individual learner differences and

- indicate how much has been learned since that time, and
- what implications it has for game designers.

Unfortunately, I do not believe that much additional evidence has been accumulated, and those studies that have been done have suffered many of the problems of the early studies (problems which I now realize are much more generic to the type of research and derive from a large degree from educational politics and problems of support rather than to limited or sophistication of te researchers).

But I have also found some problems in my own formulation. Think for a moment of the last point I made, that students are in a treble role: the simulated role, a player in a game and a student in the class. The focus and concern of game designers has been generally only on the first or on the first and second.
That is, we concern ourselves with the quality and qualities of the simulated role: Is it realistic? Are players given the correct resources? Are the constraints on actions similar to the real-world role player's constraints, etc. When we look at the student as a player in a game, we concern ourselves with such questions as: Are the instructions clear? Is the game interesting for people in different roles? Is the tempo fast enough? Is there enough feedback?

But we neglect the 3rd dimension: the student/player is also a student in a class. Thus not only must the pregame factors suggested above be taken into consideration in evaluative studies, but we must think about them when we design and employ the games. And more critically, we must think about how game performance and learning might effect post-game relationships.

In the early formulation, speculations were offered about the effect on classroom structure and relations, but the list now seems to me to be incomplete. Furthermore, like the earlier propositions, these were all phrased positively. While the phrasing of the claims on attitude change allowed the possibility of negative change (it only said participants would change their attitudes), the claims about cognitive learning posited increased learning (nobody suggested that participation might lead to greater confusion than had existed before), and the items about general affective learning talked of increased selfawareness and increased potency, but did not mention the possibility of negative self-esteem, lowered morale, or a decrease in one's sense of efficacy as possible results of participation in games. In the last proposition (on class structure and relations), it was assumed that participation would make no difference (the null hypothesis), or that it would improve relations within the class.

If my earlier concerns were that we thought of students as homogeneous, I realize now that we nonetheless thought of them as individual learners in the classroom. But each player also has that role as a student in a class, and a class is not just a collection of independent individuals. Prior to introduction of the game, there are patterns of like and dislike, trust and distrust between students and between students and teacher. Some of these are based on "personality" factors; some are based on race, religion, ethnicity, or gender; some are based on demonstrated competence and achievement. There are also elaborate ways students develop and maintain "reputations" with each other and with the teacher. And a game, it seems to me, may challenge and effect these relationships and reputations, for better of for worse.

Yet nowhere in the list of claims is there attention to such factors as the student's view of himself or herself as a learner, as competent or incompetent in a number of areas (only general feelings of potency are mentioned); no attention is paid to relationships between students, to liking or disliking, trusting of distrusting them, to better understanding of other players as people -- for example, more knowledge of who they are and what they think and believe. Neither is attention paid to responses to particular social categories player/students represent (not in their simulated roles, but in real life). For example, what if members of a minority perform poorly and are seen as the cause of failure of one's group? Do players make generalizations from that? What if there is high competition between players? What does this mean in terms of post-game interpersonal relationships?

Our initial claims now strike me as incomplete -- as naive in their assumption that if interpersonal relations were effected, they would be effected in a positive direction. It is like the early hypotheses about the effects of interracial contact: if only people would get to know one another better, there would be more harmony. We now know that is not the necessary outcome.
Similarly, we should tink about the hypothesis that gaming will improve interpersonal relations in the classroom and ask "under what conditions?"

Those interested in gaming have perhaps gone further than many other educators in recognizing the potential of group effects. They have taken to heart theories and data about the social nature of learning, and attempted to structure classroom experiences in which students learn from one another. Seymour Sarason urged that:

By and large, however, teachers do not think in terms of how a group can be organized and utilized so that as a group it plays a role in relation to the issues and problems that confront the group......

In their training teachers have been exposed, almost exclusively, to a psychology of learning that has one past and one present characteristic: the latter is its emphasis on how an individual organism learns, and the former is that the major learning theories were based on studies of the individual Norway rat.

If instead of putting one rat in the maze they had put two or more in the maze, the history of American psychology would have been quite different. Conceivably, the social nature of learning might not need to be rediscovered. (Sarason, 1971: 190).

Though we have tried to utilize group dynamics for learning, however, I think we have stopped too short in our reflections on the full implications of using the group. There are three main areas that I think we must more deeply concern ourselves with in designing games and later in using them. Let me present these briefly, and then expand upon each.

First, we know that groups are powerful agents of attitude change. Despite the paucity of evidence on attitude change from game participation, there is strong theoretical support for these claims, and research in other domains suggests that more careful study in gaming situations might well reveal this outcome. If so, we must direct careful attention to the values that are built into games, deliberately or inadvertently.

Second, there are a number of group dynamics outcomes to which we have paid insufficient attention.

We have thought if we put several students together in a situation in which they must cooperate in order to successfully compete against other groups, we would foster better relationships. But researchers in other domains have noted that there may be negative results in terms of attitudes towards others and interpersonal relations from such group competition -- especially in terms of members of groups that lose. Again, I note that this research is not research done in game situations. But it is perhaps even more important to us because some of our losers are such not by lower ability or less effort, but because we have deliberately given them unequal resources to win because their real-world counterparts have unequal resources. To simulate accurately, we have created conditions for failure in some groups and generated feelings of failure in attaining group goals or in "winning the game". But now, I suggest, we must ask what consequences this has for interpersonal relations in the classroom.

Third, we have often argued that a virtue of gaming is that students cannot be passive recipients of information from the teacher, but we must be active participants in the learning process. To be a more active participant, however, means the student must offer a "performance" to an audience of fellow students. In that performance, personal revelations will be made: the students may be required to reveal values of attitudes that could be kept to themselves in the traditional classroom. Or they may be forced to show their aptitude or ineptitude at various things to other students, as well as to the teacher.
One's skills, knowledge, and values may thus become much more "public knowledge". I think we must ask about the personal consequences of this to the student, and ask how many protections we offer for the student who is threatened or hurt by making these revelations.

I am not implying by these three concerns that they are problems in the pejorative sense. Rather, I am suggesting that group dynamics factors must be given more consideration than has been the case to the present.

One could, I suppose, argue that these concerns are for the teacher. I do not accept this. My stance has consistently been that game DESIGNERS have a responsibility to both the operators and the participants in their games.
They must be specific about what the game model is, about what outcomes are expected and which ones possible, and must offer guidance about how to effectively employ the game and to what ends.

The remainder of this paper is not an exhaustive review. Rather, it is an attempt to suggest the kinds of things we might think about in applying knowledge of group dynamics when designing and using games.

Let us look first at groups and attitude change, and the implications for game designers. Michael Zey, a graduate student in sociology at Rutgers, has written a useful summary of some of the current literature on the potency of groups in influencing values and attitudes (Zey, 1979). Some researchers, studying adults in organizational settings, have noted that the formation of recruit peer groups increases the likelihood of successful organizational socialization (Evans, 1963). Becker (1963) claims that when a "cohort" group experiences the socialization program together, the outcomes are likely to be more uniform than if they had been processed individually, as the group serves as a mediating force and, on a primary level, acts as a direct socializing agent. Van Maanen argues, "virtually all organizational members are part of a smaller group which constitutes a key source of learning" (1976: 93).

Research in other contexts yields similar findings. In an analysis of several experiments in group behavior Kurt Lewin deduced a number of conditions necessary for the occurrence of attitude change in the individual. A main point of Lewin's argument is that a group procedure for changing social conduct is more effective than an individual method. Lewin claimed that "experience in leadership training and in many areas of re-education regarding alcoholism and delinquency indicate that it is easier to change the ideology and social practice of a small group handled together than of individuals". (1952: 472) He suggests that the individual is unwilling to depart too far from group standards, so that a group change will lead to an individual change-- a claim reflected in later "reference group" literature.

Lewin had also observed experiments involving manipulation of food habits in laboratory settings, and had noticed that various lecture methods did not attain the desired value changes in the subject. He argued that "Lecturing is a procedure by which the audience is chiefly passive. The discussion, if conducted correctly, is likely to lead to a much higher degree of involvement.... Although he may physically be part of a group listening to a lecture, for example, he finds himself psychologically speaking in an individual situation," (Lewin, 1952: 465). On the other hand, "if the group standard itself is changed, the resistance which is due to the relationship between individual and group standard is eliminated". (Lewin, 1952: 472).

E.H. Schein has expanded upon the process by which the participative group allows for value change in the individual. Basing his analysis on Lewin's process description, Schein refers to the "unfreezing" of a new members old values which are at odds with the organization's values.

In Schein's view, the organization provides a series of upending events which lead to the failure of the individual to receive confirmation of self. At this point, the subject is motivated to seek what Schein calls "psychological safety" by rearranging his expectations and/or self image. (1972)

This theory is heavily based on the expectancy theories of Lewin, Fishbein, and Festinger, which see attitude change as primarily a social influence process relying on communication. Summing up a number of expectancy theory studies Cohen states, "group decision may be effective, then, because it trades on the pressure in a group toward conformity to group norms.... these pressures can help to bring about adherence to a new norm the group had adopted." (1964)

While this body of material provides continuing encouragement for investigating the claim that games are effective instruments of attitude change because they entail group dynamics, it also should support the need for caution. If simulations indeed do change attitudes, we must be clear about the direction and desirability of changes. Sarane Boocock, Garry Shirts, Nancy Glandon, and Jaquetta Megarry are only a few of the persons who have urged we must pay careful attention to the value implications of games and to the type of attitudes they may foster.

At the ISAGA meetings in Caracas, John Gagnon and I presented a paper in which we argued that no games are value-neutral--all have the values of the designer built into them either explicitly or implicitly. That paper has recently been published in a revised form in Simulation and Games, (1979) and thus I shall not take time to reiterate the thesis. But I cannot emphasize too strongly my belief that since games seem to have the potential for attitude change we must be very careful about the values we build into our games, we must make more sensitive and conscious decisions, and we must be much more explicit about these in the game manuals we prepare for users.

There is no way to avoid the game being a form of "propoganda"; but at least we can be open about what it is advocating, so teachers and other operators can make their value judgments about whether to employ it. Hopefully, they will point out the game biases to participants so they, too, have greater freedom of choice.

My second area of concern is with the possible consequences of group activity in games for post-game interpersonal relations. A vast literature has arisen in the social sciences examining some of the interpersonal carryovers of group participation under different conditions.

For example, several researchers studying communication patterns in task-oriented groups have found that persons occupying central positions in communications networks, and hence participating more, had higher group morale than persons occupying more peripheral positions (Bavelas, 1950; Bavelas and Barrett, 1951; Leavitt, 1951).

The same conclusion was reached in a number of industrial studies focussing on a special type of participation, namely participation in decision-making activities (Coch and French, 1948). What are the implications of these findings for us, as we put students into roles in simulations in which, as I noted earlier, one finds both unequal participation and different degrees of decision-making?

Other important research has shown that it is not just putting people together in cooperative groups that is important, but how this group cooperation is rewarded and whether it leads to success.

James Michaels (1977) suggests that there are four "pure" types of reward allocation employed in schools:

1) IC - or Individual Competition. Here rewards are differentially allocated among individuals according to their relative performance (as when grades are given on a curve).

2) GC - Group Competition. Here rewards are differentially allocated among groups according to their relative performances (and usually equally within the group).

3) IRC - Individual Reward Contingencies. Here each individual is compared with previously established standards to determine reward allocation.

4) GRC - Group Reward Contingencies. Here each group is compared with previously established standards.

In the competition situations (IC and GC), there is negative reward interdependence among units, for standards are set by other competitors. With reinforcement, there is general independence among units, for standards are set by external units.

Michaels then reviews several studies that examine the relative effectiveness for academic performance -- cognitive learning -- and concludes that for students on the whole, Individual Competition is better than Group Competition, Individual Reward Contingencies seem to be about the same as Group Reward Contingencies, and Individual Competition is better than Individual or Group Reward Contingencies for bringing about cognitive learning.
Group Competition may be better than Group Reward Contingencies, but the evidence is incomplete. Table 1 summarizes these studies.

If we are concerned with cognitive learning, then we as game designers, must pay attention to these findings. But Michaels also points out that while the overall superiority of individual competition appers clear. Individual Competition is not equally effective for many studies, particularly the initially low performers. Thus the traditional classroom reward structure, based on Individual Competition, may be largely restricted to the top third of the class, for these are the students who are apparently most responsive to it.

If we are going to claim that games are useful because they get everyone involved, then we must ask whether everyone is involved in a gaming situation based on individual competition. If so, perhaps we are putting old wine in new bottles, and will not really achieve our aim of reaching the harder-to-reach students who are not motivated by conventional techniques. Perhaps our games ought not contain a great deal of Individual Competition in order to be effective with them. Again, we must learn who learns most from games, not just overall impacts.

In addition, Michaels notes that both IC and IRC structures are relatively ineffective in strengthening such group process variables as collaboration and coordination, interpersonal attraction, and positive attitudes toward achievement. Group Competition and Group Reward Contingencies both have better success in these. That may be cause for some pleasure to us, since many games employ students in group situations, and thus we should be able to hypothesize possible gains in these areas.

But it is not that simple. While, as I have urged earlier, game designers have often built in small groups as elements in their games, it seems to me that these groups are usually in competition.

In other words, the Group Competition reward structure is most typical.

Furthermore, although groups are often in competition-- for example, to get to the most policies passed -- their competition is not only based on the usual questions of different inabilities and efforts, but is further based on the differential resources of their simulated roles. For example, my group many consist of smart people who try hard, but we are playing ghetto residents and have far fewer resources than does the group playing the taxpayers' association. They are bound to get more policies passed, no matter what we do; thus we are bound to lose in the competition.

The reason I worry about this is because several studies have concluded that these positive group relations outcomes mentioned above may derive not simply from group effort, but from the outcomes of the group cooperation... particularly whether there is success. Blanchard, Adelman, and Cook report that "members of successful, face-to-face cooperating groups liked and respected their group-mates more than did members of similar but failing groups.. The satisfaction generated by group success (and the rewards accompanying success) is associated with those who are involved in the group activities. This reward generalization, or spread of affect, results in increased intermember attraction". (1975: 1026) Furthermore, there was a lowering of respect and liking that occurred where members felt there was group failure.

These researchers suggest that in conditions of enforced desegregation in schools and industry, where interracial or interethnic groups are assembled, the degree of liking and respect vs, dislike and diminished respect that results may depend upon whether groups that cooperate experience success or failure as a result of their efforts. We must take the same evidence and ask about the results for interpersonal and interethnic relations if we put students in games emphasizing group competition with only one group winning and others losing.......

In another important paper, Weigel, Wiser, and Cook begin by noting that the results from a number of studies suggest that cooperative contact seems to promote constructive interethnic relations, while competitive contact seems to hinder them. The problem, they suggest, is that American schools generally produce a classroom atmosphere that is heavily loaded in the direction of rewarding competitive as opposed to cooperative behavior (1975: 222-223). While participation in cooperative groups may lead to more favorable evaluation of ingroup performance and more liking of ingroup members (Ferguson and Kelley, 1964), intergroup competition may lead to negative ratings of other-group members, and re-direct friendship choices after the competition (Sherif, et al., 1955 and 1961; Diab, 1970; Sussman and Weil, 1960). Blake and Mouton, examining adult workshop groups, found that other-group representatives were rated less favorably than they had been earlier on traits like intelligence and maturity; this was only true, however, for ratings by members of the losing groups. To the extent then that we design games in which group competition is a major factor, we must be alert to these possible outcomes.

Weigel, Wiser and Cook also asked about the effects of formation of groups which were not in competition with one another, but which approximated Michaels' conditions of Group Reward Contingencies -- that is, where the standard was outside rather than relative, and thus several groups could experience success. They found that cross-ethnic hostilities were lower in classes with cooperative rather competitive learning. More significantly, crossethnic helping was much higher. Thus, the experience led to a significant change in interethnic interaction (though not in interethnic attitude of friendship) even though the experimental group spent only a small portion of the day in such cooperative enterprises.

It seems to me that there are several ways we, as game designers, can utilize these findings. First, by knowing this, we can be more specific in our instructions to operators for post-play discussion. We must point out this possible effect of group competition, and strongly urge that they focus on these feelings in a de-briefing session.

Second, where our concerns are with fostering better relations between students, we may wish to reduce the degree of intergroup competition in our games. One way to this is to include multiple measures of success. For example, we could have students and operators judge success not simply in terms of whether a group won an election or passed more policies, but also on whether they argued effectively, made the best use of the resources that they had available, etc. In such a fashion, more students and more groups might emerge from the experience with a sense of having been successful and thus not taking on the positions and feelings typical of those who feel their efforts have led to failure. If success has consequences for self-esteem and intergroup relations, perhaps by creating more success, we can foster more of those other elements.

A third possibility open to us is to stress far more the overall cooperative character of the class's simulation participation. We can emphasize the cooperative character of the enterprise, highlighting to students after play, that while they may have competed with one another in their simulated roles, they have cooperated in making the simulated system "work". Perhaps the parallel is to a theatrical performance in which people have different parts to play. We can note that because some people experienced the frustration of inadequate resources or lesser power, and acted on this in the way real-world persons act, that we were able to re-enact in the classroom a scenario that takes place all the time in the real-world. Thus a cooperative goal -- making the game work, the simulation operate -- could be emphasized over the competitive sub-group or individual goals within the game itself. This perhaps would undo some of the potential negative effects of individual and group competition, and create greater cohesion in the class, which as one large group could feel successful.

Finally, we can strive to design more games in which groups work in tandem, rather than in competition. The frame games Dick Duke and I designed -- IMPASSE?, AT ISSUE, and THE CONCEPTUAL MAPPING GAME (Duke and Greenblat, 1979) -- are examples of games that operate by principles of Group Reward Contingencies.

In summary, if competition in the game frequently results in a sense of failure for most students, and if a sense of failure is counterproductive with regard to promoting attraction and favorable attitudes toward others, then we must find procedures which assure many winners rather than many losers if we wish positive interpersonal outcomes.

Finally, let me briefly mention the problem of personal consequences of participation in games. In the original paper I noted the following:

Where involvement is high and manifested by severe frustration, anger, depression and so on, are these 'costs' to students that must be weighed against the gains? And how do these costs compare to those stemming from the frustration, anger, and depression created when students are 'talked at', kept still and obedient, and the like in the regular classroom?

While I still believe this is a real and important question, I think there is another side to it. In the traditional classroom, the student can keep much of his or her feelings and attitudes private. One can reveal as much or as little as one wants, unless the teacher calls upon one to answer a question (and several studies have suggested that, at least at the college level, faculty generally do not call on students unless they volunteer). In a game, however, one must reveal much more. In some games, one is asked to reveal one's own values and attitudes; in others, one is given a role profile and asked to argue and act in terms of values and attitudes that are spelled out.

Eliezer Orbach has argued that this is a salient characteristic of games designed to create attitude change. Urging that for attitude change, games must have high degrees of role play, he continues: "What is an adequate set up for role play simulation then? I suggest that an adequate set up is one that ensures the expression of personal opinion and feelings on the part of all game participants." (1977: 356) Thus, in The Marriage Game (Greenblat, Stein and Washburne, 1977) players are asked to express their personal values; in other games they are told that they should play to maximize certain values such as keeping the neighborhood free of "undesireable elements", increase their own power, or keep woman in subservient positions.

But recall my urging that before, during, and after play, players are students in a class. We are forced, I believe to ask what costs they may pay by making these revelations. Is it an invasion of privacy? May the things they reveal about their "real selves" jeopardize their relations with classmates? We may argue that "openness" and "honesty" and "truth" are important, but do students have the right to decide how much openness and honesty and truth they want in their friendship and associational groups?

What if these revelations are later used against them? I tried to highlight this problem yesterday (Greenblat, 1979) in describing the game that Linda Rosen, John Gagnon, and I designed to deal with adolescent sexual-decision-making. There we assigned values that were known from research to be typical of adolescent males and females rather than asking players to set the values themselves. This design decision was made to avoid players-- especially females -- later being subject to pressure from others because they had revealed the relative importance of sexual gratification in their heterosexual relations.

But assigning roles with built-in values may not altogether deal with the problem. Can others always distinguish the "real person" from the one played, especially where the player has fine thesbian talents? The better the player plays the role, the more difficult it may be to disassociate him or her from the performance when it is over. Do you really know you think women should be given equal rights even though you expounded highly chauvinist views for 2 hours at the game designer's instructions?

I am not urging that students should not have to engage in these revelations or role plays. It is these very dimensions of break with the psychological isolation of the traditional classroom that may be most responsible for growth and learning. Unless students have to put more of themselves "on the line", have to take positions, have to negotiate and bargain and debate with others, they are unlikely to learn and grow as individuals. The educational process is, or should be, more than an accumulation of facts and principles. It should also include the development of judgment, a stronger understanding of oneself and one's view, openness to divergent opinions and new information -- and all these require that they participate more fully than they do in the lecture format.

What I am urging is that when we ask students to pay these costs by relinguishing some privacy, we must be prepared to help them deal with the consequences. They must be protected from over-revelation, and guided in the post-play discussion to new insights into themselves and others that make the costs worthwhile.

I do not have any easy answers to do this, but I think we must pay attention to the problem, both in the design of the games themselves, and in the instructions to operators about leading a post-game discussion.

As I began writing this paper, I talked about some of the ideas with a friend who has considerable familiarity with gaming. She said, "I think they are important points you are raising. But how can designers deal with them, and how can researchers measure those possible outcomes to know if they are really problems in games?" I responded to her that writing the "first paper" is the easiest job; one needs to point out the problems. The subsequent papers are much harder, for one must then deal with possible solutions. I hope to return to ISAGA another year and hear some of you offer more concrete advice than I have been able to this morning about how we can better meet our responsibilities to those individuals and groups who participate in the games we design.

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3.3 Dr. R. D. Duke, professor in the Department of Urban Planning, The University of Michigan, Ann Arbor, Michigan, USA.

Nine steps to game design.

Each gamer develops an approach to gaming/simulation that suits their paricular need. While these share some methodology they differ dependent on both the clients objective and the gamer's philosophy. My own perspective is that games lend themselves particuarly to transmitting the character of dynamic systems; consequently my approach to design is toward achieving that objective. Below are the nine basic steps to game design which I pursue in a disciplined way each time I create a game for a client:

1 Specifications for Game Design.

These are the specific set of requirements, agreed to in advance by the game builders, describing the expectations and limitations of the game. Before game construction actually begins, the building team needs to determine their game's purpose - the message to be communicated and the mean of conveying it. Game architects need a blueprint composed of carefully delineated, detailed game specifications. At the outset, they need to conform to a plan, providing a clear, concise picture of the product to be created.

This prevents unexpected, costly problems from arising later on in the process. Two resulting advantages:

a. Time-Saver.

Agreeing to specifications first tends to speed the design process along. Efficiency is increased since unforeseen obstacles to progress have been eliminated.

b. Client-approval.

The intentions of the client and game designers must correspond. By drawing up game specifications and giving the client something tangible to review, communications can ensue. This permits real differences in message interpretation, purpose, or content to be resolved at the start. These specifications serve, at the conclusion of the field trails of the exercise, as the basis for evaluation of the total effort.

2 Comprehensive schematic of systems components.

A specific description of the problem with which we are concerned expressed in systems terminology - this is usually achieved through developing 'Snow Cards' by brainstorming, literature search, and interview of experts; in turn, these 'Snow Cards' are then organized into one or more convenient formats (sequential as in a table of content, conceptual mapping wheel, three-dimentional construct, flow chart suitable for conversion of the system to a digital computer program, other).

3 Selection of problem components to be gamed.

The purpose of gaming simulation is to provide a basis for organized communication about a complex topic. To achieve this objective it is necessary to abstract from the problem set or system those ideas or problem components

which require further discussion. This process of abstraction must be guided in the particular by the specifications for game design described earlier.
The process itself is quite simple and straightforward. Using one or more of the systems representations above (either the conceptual mapping wheel or the flow chart, for example) and a colored marker pencil, the designer circles those aspects of the system which are considered essential to be included in the game.

While this is perhaps one of the most straightforward physical tasks of game design, it becomes one of the most critical in terms of the quality of the final product. There is a strong tendency to put too much detail in the game in recognition of the reality that all things are linked to all things. It is imperative for the team making these decisions to constantly review the 'specification for game design' to ensure a reasonable abstraction process. The specifications for game design serve as the basis for judgmental criteria for making the decision.

4 Planning how to include selected systems components in the game.

Having decided what to game in step 3, it is now necessary to plan how to game these systems components in terms of the basic elements of gaming/simulations. This step is achieved through the use of a SYSTEMS COMPONENT/GAMING ELEMENTS MATRIX. This matrix shows the specific way(s) which a given systems component will be captured in the game design, game element by game element.

It must be understood that a game/simulation consists of twelve basic elements (sometimes defined as a less or greater number of basic elements). As a consequence, any problem to be systematically conveyed through game design must find that the problem components must be specifically represented in one or another of these twelve gaming elements (sometimes a problem component will appear in several of the gaming elements). This process of "mapping" the problem systematically into a gaming element matrix achieves several results:

1) First, it provides a record of the decisions that are made;
2) It is a rigorous methodology which permits a deliberate evaluation of each of the components of the problem to insure that it is considered in the game design phase;
3) It forces considerations, at an early stage, of precisely how, in terms of the twelve gaming elements, each problem might possibly be represented in the game;
4) Finally, it provides a blueprint for game design as described in step 5 below.

The twelve gaming elements are described below:

a. Scenario.

A scenario is simply a text outlining the plot of the game. It outlines starting conditions and describes circumstances leading into play. It deals with all aspects - economic, social and political - either presented by text or supplemented with diagrams and illustrations. Role descriptions might be considered a part of the scenario but are normally offered in the separate section of the concept report. Role descriptions will normally establish initial points or reference and discussion for the players.

b. Pulse.

A pulse is some event or problem introduced during the

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course of play to focus the players attention on a single aspect of the problem. The pulse may be either designer-induced or player-induced. It may be predetermined, random, or triggered by a certain action in the game.

A Pulse is an organizational device - used to encourage MULTILOGUE by forcing players to focus on some shared phenomena. One pulse follows another in sequence (or in complex games, several are simultaneously initiated). Each represents an aspect of the conceptual map. During play of the gaming simulation, these pulses become tangible handles which allow players to grasp the problem in detail and enter into and to explore the gestalt of the total problem situation.

c. Cycle sequence.

Cycle sequence is a relatively simple but very important part of game design. There are both micro and macro cycle sequence that must be taken into account. The macro sequence takes into account: preconditions to the game; the introductory cycle(s); the work cycles; the final cycle; and the evaluation process associated with the total exercise.

The micro cycle takes into account the sequence of things that occur within each cycle, including the initiation, action, and evaluation of each cycle.

d. Steps of play.

Steps of play are the explicit progression of activity in the game. There is a macro cycle in each cycle which includes the three steps of initiation, action, and evaluation. During the initiation, the players read the scenario, take into a cycle any pulses/event/issues that have occurred and consider any new data

available to them as a result of the previous cycle. During the action cycle, players make specific decisions according to a given order.
During the evaluation phase of the cycle, all play stops and an intellectual discussion ensues under the direction of the game operator which addresses two questions:

1) what are the actual results of the cycle just completed? and
2) how does this experience relate to the real world problem?

The final step is always recycling, which proves especially critical - the success of gaming/simulation in conveying problem gestalt is largely derived from the interactive or cyclical nature of these exercised. Learning takes place through repetition of experience. Each cycle, then, reinforces the knowledge gained previously while additional details are introduced.

Steps or play provide the game basic guidelines of progress. Each sequence denotes another set of instructions, which signals some action(s) to occur. Player participation is directed, expected, and stimulated. Players move through the game one step at a time. This makes it easier for the player and the operator. The ultimate goal of the steps of play is to increase learning and to enrich knowledge of the system or problem being represented.
During the design of a game, these steps will likely be reevaluated and redesigned several times.

e. Rules.

There are a variety of circumstances that might develop in a game which go beyond the scope of the exercise. If these are anticipated the designer can present rules which govern these cases. These should be made clear to the players at the outset, and any changes during the play should be posted in a conspicuous way.

f. Roles.

Roles are characters assigned to players with prescribed patterns of behavior. They are predicated on known realword counterparts. Participants may play a role similar to their own "real world" role, but generally it is better to permit the player to experience the game problem system from a position unknown to him/her in reality. Roles are always limited in number to those most central to the problem being studied. There are basically three ways to include roles within the game design, pseudo, gamed or simulation:

- pseudo roles are invented frequently on the spot to serve some immediate function. Examples include judges and technical experts. When the right situation arises, special participants with unique skills are employed on the spot. Pseudo roles remain unlinked to the basic rule structure nor are they process formally through the game's accounting system.
- gamed roles are built into the gaming situation framework, are played by real players and their decisions are processed by the game's accounting system.
- simulated roles exist in the accounting system but not physically in the game room itself. Often they represent broad classes or categories of people as in voting models and demographic models.

It is often useful to have simulated roles in the gaming/simulation to generate output useful to the gamed or pseudo roles.

g. Model.

Models are devices derived from the accounting system to keep track of logical processes. They may be simple or complex. They may be expressed in mathematical terms or illustrated graphically. Examples might include the representation of economic process or demographic reality. There are basically three types of models:

1 the heuristic, or homologue, model is the least sophisticated used most often to express simplicity.
2 iconic models give the physical appearance of reality while they need not act like reality.
3 analogue models parallel the real world phenomena and correspond to the real world counterparts they represent at least at some level of abstraction. Sophisticated simulation models are an example of the latter.

h. Decision sequence and Linkages.

The sequence of decisions and linkage between players' actions must be understood before the game is designed. These represent the typical sequence of decisions that players can make during a normal cycle of play. Often these are developed through the use of a matrix: across the top of the matrix are all of the gamed roles; down the left side are the steps of play. This schematic is intented to answer the question: Who is doing what, when and how. It also provides information on information flows and feedbacks, role to role and role to accounting system. Generally, this matrix depicts the activity and intellectual process of each role during consecutive steps of play.

The purpose of this matrix is to assist the game designer in visualizing the sequence of play when the game is finished.
The matrix helps to identify role linkages within the game framework, to chart the foreseen reactions of participants to events during play, and to provide an initial analysis of all gamed, pseudo, and simulated role results before play begins.

When completed, this matrix gives some early insight into the totality of the game during play. In evaluating the contents of the matrix, the need will arise to adapt or change roles for one of several reasons. Players must be more or less equally loaded so that they are all more or less evenly occupied during the presentation. It is also necessary during an analysis of this chart to insure that decisions are sequenced properly, one behind the other, so that necessary feedback takes place. Finally, the matrix can be used as an aid in explaining to others the sequence of events occurring during a typical game run.

i. Accounting system.
The accounting system is a set of fixed procedures incorporated directly into the game to deal consistently with player decisions. These decisions - outcomes of steps of play - are processed, acted upon and forwarded to some other game component, feeding back either into an indicator, model, role, or some combination of the above. An infinite variety of accounting systems exist. Game designers must develop a system suitable to the particular exercises. In the final analysis, the accounting system must be devised to deal in a rigorous and consistent way with all of the information contained in the cells of the "systems

component/gaming element matrix" described earlier in this report.

Having selected and defined the gaming elements from the "systems component/gaming element matrix", a procedure to account for their activation must be devised and implemented as an accounting system in the gaming/simulation. This accounting system may be simple or complex, it may maneuver players' responses through models, simulations or very simple algorithms, and it may or may not use small or large computers. It will always be reported out to the players through various indicators which will be displayed on forms, wall charts, and playing boards.
Whenever possible, it is desirable to have the players individually keep the accounting system. This gives them a better understanding of the problem being considered and saves a great deal of work for the operator.

Regardless of the format or the combinations employed, the accounting system will inevitably be sequential. This requires very sophisticated judgement by the builders of the exercise to ensure that the sequence of decisions, as represented by the system of accountants, at least integrates into a larger system or gestalt experience.

j. Indicators.

Indicators are those aspects of the accounting system that the operater chooses to emphasize for the participants. They report on the game's progress, the interaction of players' decisions as filtered through the accounting system and linked to the models. Like a fuel guage in an automobile, an indicator demonstrates the energy level in the gaming/simulation and provides evidence the system of play is in gear.

k. Symbology.

Symbology is the physical representation of indicators. These are visual aids comprising a set of characteristics about some gamed phenomenon. Symbology is game-specific, in that the materials lose meaning outside of the playing arena.
They are comprised of extemporaneous material like cardboard chips or wooden blocks and are integrated into the game to portray some reality such as the land-use pattern or building pattern.

Symbology may be any tangible replication incorporated into play to embellish, as well as convey, meaning. Players are asked to focus their attention on these items, to address and munipulate them according to procedures.

During this stage of the design process, experimentation with the symbolic structure occurs. It must be the goal of the gamebuilders to gain maximum clarity for the players. To minimize confusion during play, it is necessary to be parsimonious in the selection of these gamed materials.

l. Paraphernalia.

Paraphernalia includes everything else required to successfully run the simulation exercise. The material ranges from the decision forms to the wall charts to colored pens and the gameboard itself.

5 Summarize of content of each gaming element.

To build a gaming simulation, then, it is necessary to define each gaming element in two dimensions:

a description of the substantive content of each gaming element; a description of the gaming mechanisms that are thought to be appropriate for representing this content in the game. To describe the content of each game element summarize the notations from all cells for each column of the systems component/game element matrix (scenario, pulse/event, roles, decision sequence, cycle sequence, steps of play, accounting system, models, indicators, symbology, and paraphernalia).

To obtain the first information; that is, the content which must be included under each of the indicated game elements, the gamebuilding team simply makes a summary notation of all of the notations of each cell of the appropriate column from the systems component/game element matrix developed under step 5.
For example, under the column "roles", the various and sundry rows of the matrix describing the problem in a systematic way will reveal those decision-makers that have to be included.
By listing all of those going down the column, a complete list of roles that must be represented can then be included.

6 Select gaming mechanisms from your repertoire of techniques.

Next, using your ideas from your "repertoire of games", describe ideas about how each of the gaming elements will be represented. This is best done by going down the game element listing, point by point, as you list the gaming technique which seems most effective.

7 Game construction and testing.

Game construction is an interative process. The experienced game designer will actually attempt the design of the game at a very rudimentary level. These preliminary efforts are used primarily to help the game design team conceptualize the problem as it might be converted into gaming/simulation format. It is important to capture the design blueprint in a written concept report before game design begins in earnest. The concept report achieves three major objectives:

- It insures that the game designers go through a deliberate process which takes into account the several steps noted above. This is more efficient and results in better game design than in a random progression;
- It provides a very sharply delineated and documented basis for the client to review the expected product in its conceptualized stage. Gaming/simulation is a client-oriented tool and the concept report helps to insure that the final product is useful to the client;
- Finally, the concept report serves as a blueprint or working document for the design team during the construction phase.

Actual construction is a trial and error process which progresses as follows: each game element is built (designed, written, conceptualized). As the team progresses down the list of gaming elements, these are continually checked one against the other to insure that they dovetail or "fit".
When all gaming elements have been completed as initial, rudimentary, or trial efforts, a series of gaming "walk throughs" are attempted. At this point, the "rule of ten" comes into play.

The gamebuilders must recognize that the early cycles or game runs will be full of difficulties. They will be pleasantly surprised, however, to discover that by the second, third or fourth run, the form of the game will clearly emerge. To insure that the final gaming/simulation product is reasonable, testing must be governed by the "rule of ten". That is, a game should be presented as complete only after it has been tested with appropriate audiences on ten seperate occasions, the final three of which should require no further significant adjustment or modification to the gaming/simulation. The "rule of ten" goes through three more or less distinct phases:

- Trial construction or testing as an interative process. In this, the design team "talks through" the game considering various mock-ups and carrying the process through its logical processes.
- Pretesting corresponds to a "dress rehearsal". The entire product is tested with a small group of participants. Participants include the design team and a few colleagues and interested volunteers.
- Formal testing ensues after most "bugs" have been eliminated, This entails more rigorous evaluation of the finalized version before it is turned over to the client.

The client, participants, and game designers must all recognize that many different runs may be required before the game is finally calibrated. In fact, there may never be a time when a "final" game exists. More likely, the users will find that continuous modification to the game is productive throughout the lifetime of its use.

8 Game evaluation.

After the game has been completed and turned over to the client for field use, it is necessary for the client to evaluate the product. The only logical basis for evaluation of the gaming/simulation is the original "specifications for game design" described earlier. These were the guidelines approved by the sponsor in advance and they must serve as the basis for evaluating the product. At this point it becomes clear to both the game builders and the client that the more specific and plausible the original "specifications", the more clear cut becomes the final game evaluation.

9 Field use of the gaming/simulation.

Once the gaming simulation has been designed, tested, modified and retested, and evaluated, it is time to put it into field use. Field use will normally require the training of appropriate game operators. This can be accomplished through holding workshops for intended users or by trained game operators into the field to assist in the actual use of the exercise. While the operation of the game may seem formidable to the neophyte, field experience with complex games like the FAO gaming simulation "SNUS" (Simulated Nutrition System) indicates that it is not difficult to achieve adequate field use.

Finally, a distribution plan for the gaming simulation is essential. Responsibility for distributing the game must rest clearly with an existing institution or commercial firm. Such institution or firm should be authorized to duplicate the materials, train operators, and arrange for field use and demonstrations.

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Development of an interactive Simulation / Game: a case study of the development DENTIST (DENTal health care interactive simulation tool).

1.0 Preface.

The Social Systems Research Group (SSRG) is an interdisciplinary team focussing on the study and analysis of social systems with special attention to the policy- and decision-making processes in order to improve long range social planning.

Systems theory is applied for the description and analysis of social systems, and in general computer simulation models are developed and analysed. In most cases the study of a particular social system is carried out with the use of what is called "interactive simulation". This approach provides a framework for integrating different perspectives on social systems, thus facilitating interdisciplinary research.

Within this context SSRG is doing research in the following three areas:

1 Social systems science.

Methodological aspects of analysis and synthesis of social systems are studied, especially from the point of view of planning and decision-making. Elementary decision-making processes are being described and formalised.

2 Method of interactive simulation.

Effective man-computer communication is studied at a functional, procedural, and physical level. Results are integrated and applied in the design of particular set ups. Criteria for effective integration are derived from insights gained by the study of social systems science. Progressively SSRG is integrating gaming techniques with interactive simulation.

3 Applications of Social Systems Science.

SSRG has done research in the areas of energy-supply planning, personnel management, but it also has studied topics like modelbuilding as a mental proces, decision-making processes in a research department. Current research is related to:

3.1 Interactive simulation with a demographic model
3.2 Dental health care in The Netherlands
3.3 Personnel management.

2.0 The study of social systems.

During the last decades we have seen, internationally and nationally, a growing awareness of the many problems for which solutions are urgent. We also have noticed that solutions for one problem area generate or aggravate problems in other areas.
To this class of issues of broad concern belong, among others; labour and unemployment, natural resources, nutrition, arms race, pollution, health care. These deficiencies in social systems are not caused by agencies attacking them as it ware from the outside, like the plague, but are the consequences of our individual and collective actions and of the structure of societies. For most of those issues there seem to exist no simple and clear solutions, and most states do not know how to cope with them effectively.

As a result of these developments there is a growing sense of futility among the general public related to the inadequacy of the government. At the same time there is a growing need for integration of knowledge concerning our social systems. Many call for a more integrated and comprehensive approach to managing the complex processes of change, that are characteristic of our contemporary societies. Lamson (1978) has pointed out that if we are to create better understanding of and concensus about these problems and options we face, and to implement the goals and solve them, we need to engage in and support policy dialogues, informed by research, at all levels, international, national, state, region, city and local community.
A policy dialogue is a discussion about policy problems, causes, impacts and options.

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These problems form a challenge for the social sciences. Allen (1978) notes that any discipline that calls itself a science will be judged and rewarded by its success in answering tough questions - such as society is demanding today. According to our opinion the social sciences in general are not well equipped yet to deal with these social problems. We observe a growing public disenchantment with the efforts of social science to solve social problems. We are very much in favour of a social science, which in a systematic approach helps policymakers, citizens and planners choose a course of action by investigating the full problem, searching out objectives and alternatives, and comparing them in the light of their consequences, using an appropriate framework - insofar as possible analytic - to bring expert judgement and intuition to bear on the problem (Quade, 1968). This what we like to call "social systems science" is a policy science and future oriented. It is a practical enterprise that focusses on effecting change. Klabbers (1978) has pointed out that necessary conditions for dealing with these issues, as mentioned before, on a long term basis are:

- development of a systems perspective i.e., a shared image of the current situation,
- development of a system to monitor changes within the social system and its environment, to make it possible to compare favourable and unfavourable effects,
- a communication system to provide feedback and knowledge useful for all participants.

More recently we have added:

- communication tools to make explicit differences in interest, while providing means to experiment with contrasting interests at the same time.

In order to be able to deal with current problems of social systems, social systems science has to take into account their complexity, and consequently our uncertainty with respect to their behavior, and the urgency with which solutions have to be found. In order to deal with complexity it is essential that we learn to cummunicate structures, systems as "Gestalt".
In this regard the systems approach should be considered more an orientation towards methods of inquiry, rather than tools per se (Allen, 1978).

In this context gaming/simulation has much to offer. Duke (1974) has amply discussed its potentials. The Social Systems Research Group has invested considerable time and effort in developing a method, which enables the gathering and organization of quantitative, qualitative and otherwise intangible kinds of information pertinent to policy-formation and planning. Its purpose is to be able to develop a better understanding and accurate assessment of social systems, especially from the point of view of modeldevelopment that is policy-oriented. This method of interactive simulation integrates all-computer simulation, with strong emphasis on a rational and calibrated approach, and gaming, which is more susceptible to an intuitive and uncalibrated approach of social systems (see: Armstrong, and Hobson, 1973). SSRG is paying more and more attention to client or consumer orientation of modelenvelopment. The development of DENTIST is an example of the approach to social systems, as chosen by the research group. Knowledge of and experience with the real system has to be provided by those who are familiar with the system concerned, SSRG provides experience with methods of inquiry. In a joint project, a systems perspective is developed together with tools to analyse the system. In this particular case the clients are the Department of

Cariology and Endodontology and the Institute of Medical Psychology of the University of Nijmegen. The interdisciplinary research team, consisting of dentist, psychologists and system scientists, passed through all stages of the design process together. During the project it has become clear that the communication problem of participants is not that they used different vocabularies to describe the same system i.e., dental health care system, but rather that they used different structures of reasoning.

From that point of view the joint project has been extremely fruitful. It has been a very stimulating mutual learning process concerning a complex system, about which there exist many different and opposite opinions.

3.0 General structure of an interactive simulation/game.

Interactive simulation/gaming is an integration of all-computer simulation, man-computer simulation and gaming. An interactive simulation/game is developed in three stages (see fig. 1):

1 development of the simulation model,
2 embedding of the simulation model in an interactive simulation,
3 embedding of the interactive model in a game.

At each stage the system involved can be analysed from specific points of view.

Stage specific goals are:

- goals of all-computer simulation are more related to analysis of social systems at the techno-economic level, emphasizing the quantitative aspects.
- goals of man-computer simulation incorporate the prior goals but include also more qualitative aspects of individual human behavior like:

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transfer of information and skill concerning dynamic characteristics of the simulation model in the interaction with individual strategies, the study of individual values and normes, learning and exploration on how to cope with complex phenomena,

- goals of gaming incorporate the prior goals but are also related to in- and between group interaction, to human organizational aspects, to communication, social learning and policy-formation.

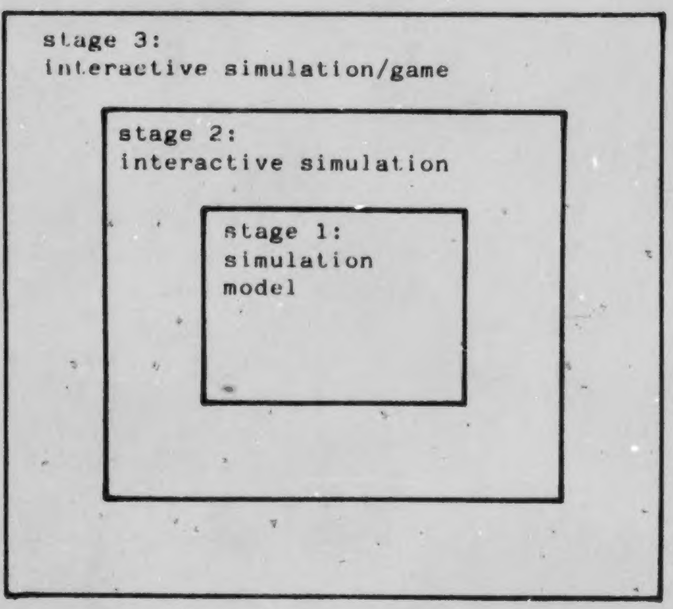

Fig. 1. Structure of interactive simulation/game

4.0 Specification for an interactive simulation/game.

In section 3.0 it has been mentioned that an interactive simulation/game is developed in three stages. In this section these stages will be described rather detailed.

4.1 Development of a computer simulation model.

As the process of modelbuilding of social systems in relation to interactive simulation has been discussed extensively (Klabbers, 1975-1, 1975-2, 1976), here it will suffice to mention the steps in the design process. Two phrases will be distinguished i.e., a conceptualization phase, which in general consumes about sixty percent of time and effort of this first stage, and a formalization phase, during which the mathematical model is developed and analysed. The development of the simulation model will progress through the following steps:

conceptualization:

1 problem identification
2 formulate the problem
3 define the time horizon
4 choose system boundaries
5 choose level of aggregation
6 define the elements of the system
7 define matrix of cause-effect relationships or draw a flow diagram of causal relationships
8 make a verbal description of processes indicated by step 7
9 verify this (qualitative) model

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formalization:

10 map causal network into mathematical system i.e. allocate elements of the qualitative model to system variables
11 define system equations
12 choose appropriate programming language and program mathematical system
13 estimate parameters
14 perform sensitivity analysis

15 carry out scenario analysis
16 compare the results of the analysis with available knowledge about the actual system
17 draw consequences

It should be stressed that during the conceptualization phase the steps 1 - 9 do not mean a strict sequence. Underlying the sequence as presented here is the assumption that first the structure of the system involved is known, and that afterwards can be derived the way it functions, thus providing a description of the characteristic processes. In many cases this situation is reversed and those who provide information about the system to be studied describe it in terms of ongoing processes.
In such a situation step 8 will become step 3, while step 3 etc. move up.
Especially during the conceptualization phase one should be flexible, starting at a high level of aggregation, and being prepared to go into detail later.

During step 6 the elements of the real system will be defined. However those elements have a concrete meaning in reality, but they cannot be used while developing an abstract system. This implies that to each element of the real system one or more attributes will be attached. These attributes become the elements or abstract objects of the abstract system. What attributes are considered to be relevant depends to a great extent on the formulation of the problem.

4.2 Embedding of simulation model in an interactive simulation.

Since 1974 SSRG has developed and applied a software package facilitating the development of interactive models (Van der Hijden, 1975-1, 1975-2, 1978-1, 1978-2). During the stage of the design of an interactive simulation, the following steps are distinguished:

1 define the purpose of the interactive simulation
2 selection of computer hardware and software
3 definition of the decision structure
4 selection of the mode of interaction between humans and computer
5 specification of the dialogue program
6 coupling of dialogueprogram with simulation model
7 use of interactive simulation

1 Purpose.

It is not self-evident how a given simulation model has to be embedded in an interactive simulation (system). One particular model can be the nucleus of a series of interactive simulation systems. Before the design of an interactive simulation starts, it is necessary therefore to state clearly which purposes are intended for the particular system.

Relevant questions are:
- How realistic should the system be? Is it intended for demonstrations only, or will it be applied in a learning/decisionmaking environment?
- Who are the users? Will the system be managed by somebody who has participated in the design process, or will the "operator" be an outsider?
- Which equipment will be used? On what kind of computer configuration does the interactive simulation system have to run?
  Should the system be portable to other computer configurations?

- What costs are involved in what period of time? When has the system to be operational and how many working hours are available upon that date?

The answers to these questions and especially to the last one define the constraints for the design process.

2 Selection of computer hardware and software.

Although there exists a broad variety of computer equipment, of man-computer devices, of operating systems and programming languages, it often is not possible to select hardware and software in a way that reflects as much as possible the requirements of an interactive simulation system. One simply has to use the facilities which are available at a certain location. Nevertheless some remarks will be made, which may be suitable for other users, and that are based upon our experiences so far.
The first is that a minicomputer with a user-friendly operating system and a general purpose programming language constitutes a good base for the development and use of interactive simulation systems. The second remark is that it may be fruitful to make a distinction between the host computer configuration and the target computer configuration. The host computer will be used for development of the interactive simulation system, the target computer only for running the system. Especially the microcomputers as they are becoming available now, could serve as target computer configurations for smaller interactive systems. The current versions are less suited for the developmental work, but this situation is changing rapidly and it is not impossible that within a few years microcomputers can perform the same functions as minicomputers in this area of application.

With respect to man-computer communication devices, until now we have only practised communication in the form of written language.
The devices used are so-called alphanumeric terminals: a videoscreen for the presentation of text as output from the computer and a typewriter keyboard for sending a message from the user to the computer. Although other forms of communication devices are available, i.e., voice input and output, we will limit ourselves in the following discussion to alphanumeric terminals.

3 Definitions of the decision structure.

In simple terms, the difference between a computer simulation model and an interactive simulation system is, that during an interactive simulation human users can obtain information concerning the model, and can change certain variables of the model at run-time. Depending on the specific purpose of the particular interactive simulation system, different roles of human decision-makers are identified. These roles have a strong correspondence with the roles of the players, to be discussed in the next section, although they do not have to be identical completely. For each role model-variables that can be observed are defined.

4 Selection of mode of interaction.

As stated before all messages that are interchanged between human users and computer are alphanumeric. The actual communication can be performed according to two different modes:
the command mode and the dialogue mode. In the command mode the user takes the initiative for each interaction with the computer. The user knows a set of commands or even a command language and types the

desired command at his (special) typewriter keyboard. Next, the computer responds. In the dialogue mode the roles are reversed. The computer takes the initiative and presents to the user a menu of options. The user responds by simply typing the number of the desired option. So he does not have to know the commands from memory. The dialogue mode of communication is better suited for casual users. Usually this category of people most frequently is involved with the use of interactive simulation. Therefore we will restrict ourselves in the following step to the dialogue mode of communication.

5 Specification of the dialogue program.

The dialogue program is made of a branched sequence of interactions. Each interaction consists of a fixed text with (optionally) some numbers inserted to it. During the interactive simulation session this text is displayed on the user's videoscreen. Then, the computer waits until the user has entered a response. The dialogue program 'knows' which responses are legal. If the user has entered an illegal response, an error message is displayed automatically and the interaction is repeated from the beginning. After a legal response the next step of the dialogue is started. Due to the facility to have branches and loops in the dialogue program, the selection of the next step of the dialogue can be dependent on some prior user response.

The dialogue program of SSRG is subdivided in two components which are called the dialogue structure and the dialogue text. The dialogue structure describes the dialogue in terms of the branched sequence of the interaction process (steps in the dialogue) and the specification of the legal responses on each interaction, but is does not contain the actual text as displayed on the video screen. The latter is dealt with separately.

The reasons to introduce this distinction are:

- the implementation of the dialogue program can be performed more efficiently, because the skills which are needed to make a dialogue program are separated in two different jobs which only are related loosely: the implementation of the dialogue structure and the implementation of the dialogue text. The former has to be performed by a programmer, the latter by the modelbuilder.
- all changes in the lay-out of the texts as displayed on the screen can be performed without any programmer's intervention. It even is possible to realize the dialogue in different natural languages or in one single language but with different levels of sophistication, without any additional programming. Only a new version of the dialogue text has to be provided.

6 Coupling.

Once the dialogue program has been finished, it has to be linked with the simulation model. After some testing and adaptation, the interactive simulation system is ready to be used.

4.3 Embedding of interactive simulation in a game.

If the decision is made to develop the interactive simulation system further into a game, the following steps should be taken into consideration: (see also: Klabbers, Geurts, Smits, 1978)

1 specify purpose of the game
2 define the role(s) of the players in relation to the decision structure
3 define the steps during the game
4 make role descriptions
5 test and adjust the game
6 run the game.

Dependent on the set up of the interactive simulation several games can be developed. What have the game designers in mind, will the game be a teaching tool, will it be used for research design or for pre-planning or planning? If for example the game will be used for pre-planning or policy formation, much attention should be given to registration and analysis of alternative strategies and their effects on the evolution of the system. The players may also be interested in forecasting options. In the case of using the game for planning purposes the players may need optimization options using different criteria for optimization.
DENTIST as it stands now, has been developed primarily as a teaching/dissemination and research design tool.

In the next section the development of DENTIST will be discussed on the basis of these specifications. We will select those stages and steps, which we think are of interest to those who involved in gaming/simulation. For this reason we will focus on the conceptualization phase of the development of the simulation model, and on the embedding of the interactive simulation in a game.

5.0 An outline of the development of DENTIST.

5.1 Development of the simulation model.

1 Problem identification.

In The Netherlands efficiency and effectiveness of the health care system is becoming more and more a subject of thorough discussion. Both the goverment and the consumer organizations, dealing with health care are insisting on structural improvements. A similar criticism applies to the dental health care. During the last decade at least twenty five reports have been published concerning dental health care in The Netherlands. In most of these reports a partial view of the system as well as differences in opinion about the demand of dental care are expressed. These differences of opinion about the demand of dental care are the consequence of the disagreement concerning the meaning of the concept 'dental health'.

What is lacking so far is a more comprehensive approach to care delivery.

Van der Wolff (1979) has expressed this as follows:

"The way medical care is being managed looks like a carnival.

Disguised in our best intentions, with the mask of the renovations we aspire, with in our midst the patient to whom it all concerns, we celebrate the carnival of the medical care".

This statement, although directed to the medical care in general, fits the dental health care well.

What is needed is knowledge and insight in the many factors that are of influence and in the way they are interrelated.

2 Formulate the problem.

"How will supply and demand of dental care evolve over time, taking into account different opinions regarding the concept 'dental health' and alternative policies aimed at improving overall care delivery".

3 Time horizon.

Looking at the average training time of dentists, about seven years, and the long delays in effects of measures by the government on the general public, a time scale of about twenty five years seemed appropriate.

4 System boundaries.

We have restricted ourselves to the dental health care system as such, which is a subsystem of the medical system.
The relevant environment of this subsystem is constituted by:

- government and insurance companies
- the profession of dentists
- general public i.e., the consumer/patient.

5 Level of aggregation.

Aggregation is defined as a grouping of quantities with common properties in such a way that they can be considered as a whole (Klabbers, 1975-1). As we intended to develop a model with a high level of aggregation to show the most important dynamic characteristics of the system, we have decided to direct our attention the services in general. We have not made any distinctions in treatment, neither did we pay attention to age specific demands.

6 Elements of the system.

When we started making a list of relevant attributes the client presented a list of ninety attributes. It will be clear that such a list is impossible to deal with effectively. Thus the client was asked to make a list with thirty attributes as a maximum, which is still a long list. Mutual discussion to condense the prior list started the first stage of the filtration of the most important factors which determine the structure of the system. During this step not only empirical and theoretical evidence are taken into account but also intuition and experience.
The less theoretical and empirical evidence is available, the more the team has to rely on experience and intuition.
The most important relations will be shown in the next step.

7 Causal network.

Actually the causal network as shown here is a mapping of the matrix of cause-effect relationships, which was developed first.
Once the list of attributes is defined, a matrix is drawn. Cell by cell the question is asked: " Does attribute i have a relation with attribute j, and if so, is this causal positive or negative i.e., inverse?"
During this rather thorough discussion it becomes clear that each member of the research team has a slight and sometimes even fundamental different view of the meaning of the system and the place those attributes and their interrelationships. The result of this time consuming and most of the time frustrating and hectic conceptualization process is an increased consensus about the system.

The most important relations will be shown in the next step.

7. causal network

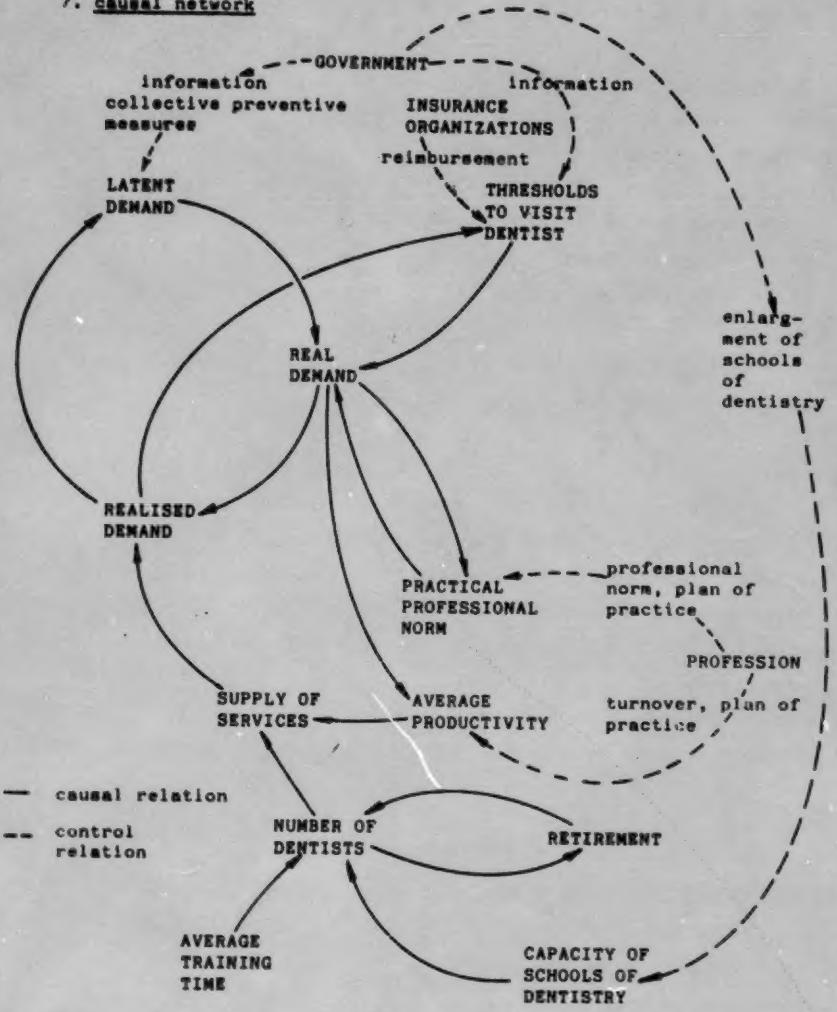

Fig. 2. Causal network of DENTIST.

8 Verbal description.

The causal network is verbalised subsequently in such a way that processes indicated by the structure become more explicit and thus easy to understand for an average (non-technical) reader. The next citation illustrates how a verbal description may look.

"Suppose that every citizen would visit a dentist, who would examine him or her thoroughly according to the highest professional standards. This registration of the oral health of every citizen then could be collected centrally, providing on a national scale the overall latent demand of dental care. This latent demand is influenced by nutrition habits, collective and individual preventive measures, such as fluoride use and dental hygiene, but also (more indirectly) by the quality of the delivered dental care.
If people consume more and more food, containing sugar, over long periods of time, and this is what is happening during the last decades, dental decay will increase and thus the latent demand.
It seems reasonable to assume that when latent demand increases the average manifest demand will increase too. This manifest demand implies having complaints, which result in restorative periodontal and prothetic dental treatments. We all are familiar with the fear to visit a dentist, although for different reasons. Some are afraid of pain, some of the bill afterwards, some are afraid of both.
All these factors cause financial and emotional tresholds. If these tresholds are reduced by government measures (education, advice) and/or measures by the insurance companies, it may help people to overcome their fear. They may no longer resist the need for treatment i.e., the real demand increases. etc.."

(The first relation between latent demand and real demand is positive: if latent demand increases, real demand will increase too. The second relation is inverse. If thresholds decrease, real demand will increase.)

9 Verification.

The verbal description has been shown to experts, who have knowledge about and experience with (parts) of the system. In this particular case, the description has been shown to and discussed with professionals working in the field of dental health care. After they had given their comments, the causal network and verbal description were adjusted.
During the verification, much attention was given to what is called 'face validity' of the verbal description or the conceptual system.

The verification step completes the development of the qualitative (or conceptual) model. Subsequently it will be formalised.
In the case of DENTIST a System Dynamics model has been built. Some results of the simulation-runs will be discussed later.
The S.D. model has been rewritten from Dynamo into Fortran.
An interactive simulation system has been developed, which runs at a PDP 11/34, with RSX-11M as operating system. The embedding of the simulation model in an interactive simulation system has been discussed in general terms. We will describe the embedding of the interactive simulation in a game in more detail now.

5.2 Development of the game.

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1 Purpose of the game.

The purpose of the interactive simulation/game is to transfer insights concerning the behavior of the dental care system.
The system is constituted by the supply and demand of dental services. Effects that different groups have on the system, each of them formulating strategies with a partial view, have to be shown to an audience which is professionally engaged in dental health care, stimulating a search for a systems perspective.
A second purpose of the interactive simulation/game is to convey insights regarding the management of complex social systems in general.

2 Definition of the roles of the players in relation to the decision structure.

Both the purpose of the game and the decision structure of the System Dynamics model, which constitutes the core of the interactive simulation/game, have led to the final choice of the game design (see fig. 3). In the game three groups of players are distinguished:

1 the group playing the government and public- and private insurance organizations
2 the group playing the profession of dentists
3 the parliament/public opinion, which represents the average consumer of dental services.

The "government" and the "profession of dentists" receive information about the state of the system, and means to implement their goals. The "parliament/public opinion" has access to all information which is available to the groups mentioned above, but it cannot directly influence the system. The parliament

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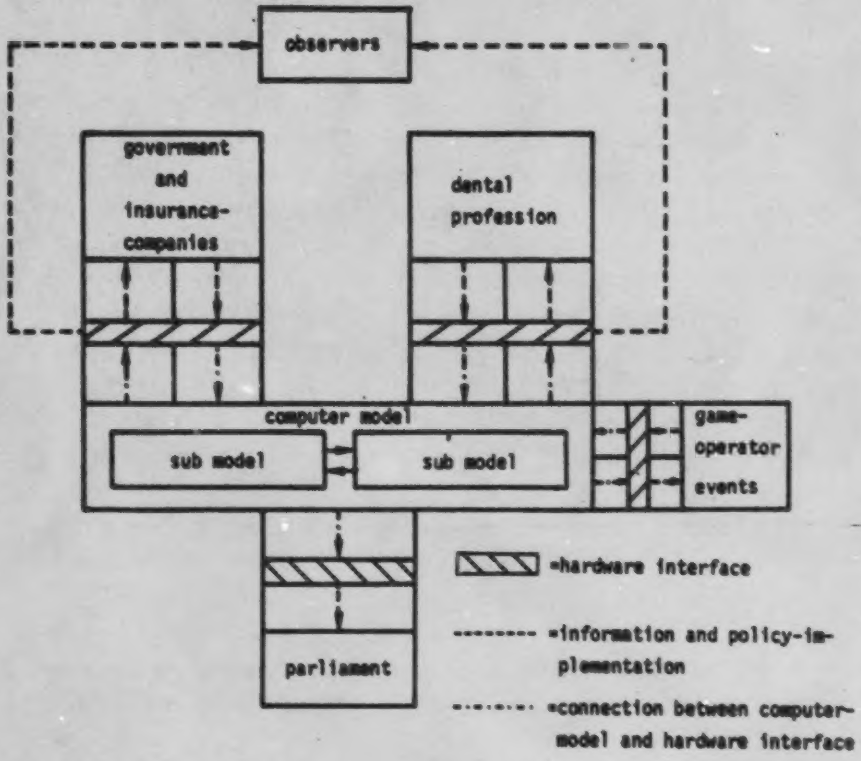
can only pursue its goals by influencing the policies of the other groups i.e., indirect control.
The government and the profession of dentists have partial and mutually different information, because they are used to observe the system form different perspectives. So the parliament/public opinion has a better over-all view, but less "power".

The game operator receives all necessary information about the state of the system, and he is able to initiate "events".


observers
government and insurance-companies
dental profession
computer model
sub model
sub model
game-operator events
parliament
=hardware interface
=information and policy-implementation
=connection between computer-model and hardware interface

The game-design of Dentist.

figure 3.

The groups and the game-operator interact with the computer via video screens and keyboard. Each group has different policy options.

The government/insurance companies:
The government receives a budget, that can be allocated to dental education, to preventive measures or, in consultance with the insurance organization, to reduction of expenses of dental care for the individual patient. It also has the opportunity to use (part of) the budget to increase the capacity of the schools for dentistry, in order to raise the number of students, that can be admitted yearly.

The profession of dentists:
The profession of dentists is allowed to determine the desired average turnover for a dental practice and the means by which this turnover should be realised. It can also change the professional standard, which determines what is considered as a dental affection. In consultance with the government the "profession" can decide to adjust the average number of hours the dentist is willing to work yearly.

The game-operator:
The game-operator can by initiating an event, induce a technological innovation, which improves the quality of dental care and the average speed with which the dentist can work. Another event changes the willingness of the population to see the dentist regularly The consumers may organise a strike and refuse to visit the dentist, or they may be stimulated to see the dentist as a result of an intensive publicity-campaign.

3 Steps during the game.

The game session consists of the following phases:

1 Preparation phase:
During this phase the players are informed about the purpose of the game, the game design, their respective goals and the steps of the game.

2 Actual gaming phase:
During each simulation period the following steps are completed:

1 goal formulation by each group
2 policy formulation i.e. how to realise the goals during that particular simulation period
3 consultation between the groups about policies pursued
4 specification of policy i.e., policy decision
5 implementation of policies by each group
6 simulation
7 presentation and evaluation of results
8 adjustment of goals and policies.

3 Evaluation of game session:
During this phase players comment on the game, exchange experience and insights. It is also possible to discuss scenario's defined for the simulation model. Special attention will be given to effects of partial observability and control on systems behavior.

4 Role description.

Each group receives a role description with information concerning the real system and the function of the group they represent in the interactive simulation/game. Possible goals are mentioned and the means with which they can be pursued are discussed.

Each group receives information from the system on which it can base its policy.

5 Testing of the game.

Once the interactive simulation/game is completed it has to be tested. Criteria which have been used for DENTIST are:

- are the goals of each group clearly defined
- are the goals realistic
- are the relations between the groups structured satisfactorily
- is the information about the state of the (partial) system presented in a suitable format
- how easy is it to process all available information.

These and other questions are put forward during the testing of the game. On the basis of the feed back received so far DENTIST has been adjusted and improved. We have to make another five runs with the game before we consider it ready for use.
So far it has been tested five times. Preliminary results are quite promising.

6 Running of the game.

Running of the game will take 4 - 6 hours an 6 - 20 players can participate.

6.0 Some results.

6.1 Scenario analysis.

With the simulation model several scenario-runs have been performed. Two scenario's will be discussed here to show possible behavior of the dental health care system as a result of the particular measures represented in the scenario's.

scenario 1:
The budget spent by the government for educational purposes in the field of dental health care is raised from 1 to 10 million guilders per year.

Dental education is assumed to have effect on both the willingness of the patient to visit the dentist and on the dental hygiene and nutrition habits of the individual/patient. Increase of the budget for educational purpose has the following positive effects. The latent demand for dental services decreases over time, while the percentage of sanified patients grows due to the increased willingness of the population to visit a dentist regularly.
The opposite side of the coin is however that the real or manifest demand for dental care does increase. This is caused by the same attitude (more positive) towards dental care as stated above.
It also causes a growing discrepancy between supply and demand for dental services. The workload of the dentists increases, and the resulting strain may cause a drop in the quality of his work, which in the long run has a negative effect on the dental health of the population in general.

scenario 2:
In this scenario the government decides to nationalise the dental health care system. This implies that patients do not pay for dental services anymore. The government and the insurance companies take care of the costs involved.

The benefits of this measure are very small, especially when related to the costs involved. An increase of the percentage of sanified patients from 30 to 40% as well as a less pronounced increase of the latent demand, in comparison with the base-run, are observed. These phenomena are caused by the lowering of the financial burden to visit the dentist. It appears however that this financial burden accounts for a small part of the over-all willingness of the patient to see the dentist regularly. This willingness increases only slightly as a result of this measure.

(The introduction of the National Health Service in England, which is a similar measure as discussed in this scenario, merely caused a growth of the demand of 20%.)

The expenditures of this measure are tremendous however. The government has to spend more than 1.3 billion dollars per year to realise such a nationalization. Due to a growing demand for services this amount of money will increase steadily.

Just like the first scenario the quality of the work by the dentist decreases because of the increase of the demand. One of the reasons is that the dental practitioner may tend to treat on the average less affections per patient, thus reducing his/her workload.

In figure 4 these scenario's are compared to each other. What is remarkable in these graphs is that a budget of 10 million guilders spent for educational purposes is much more effective in the long run, taking the percentage of sanified patients and the level of the latent demand as criteria for the effectiveness of the system, than 1.3 billion guilders and more, which is needed to finance the nationalization of the dental health care.

6.2 Observations concerning dentist.

Decisions made by the groups interfere with each other. This hinders each group in tracing the consequences of its policy, while it is not clear to what extent the observed behavior has been influenced, if it has been influenced whatsoever, by the other group. We have noticed that groups became suspicious.

In the gaming the group representing the dentists is most powerful. It is able to attain its goals with less effort than the group representing the government and insurance organizations. The parliament/public opinion group is the weakest and produces most noise.

Dentists playing DENTIST were more unanimous than laymen in expressing their view that these phenomena are realistic.

7.0 Final remarks.

The project started Juni 1, 1978, and the first test with the interactive simulation/game was performed in February 1979.
Since then we have made several test-simulations, and we have improved the gaming aspects. Now DENTIST will be used to attract more attention to the structural aspects of the dental care system in relation to policies by the respective groups working in the system. We hope to start a policy dialogue, and eventually we hope to help improve long term planning of dental care.

DENTIST will also be used as a learning and training tool for dentist students and social sciences students.

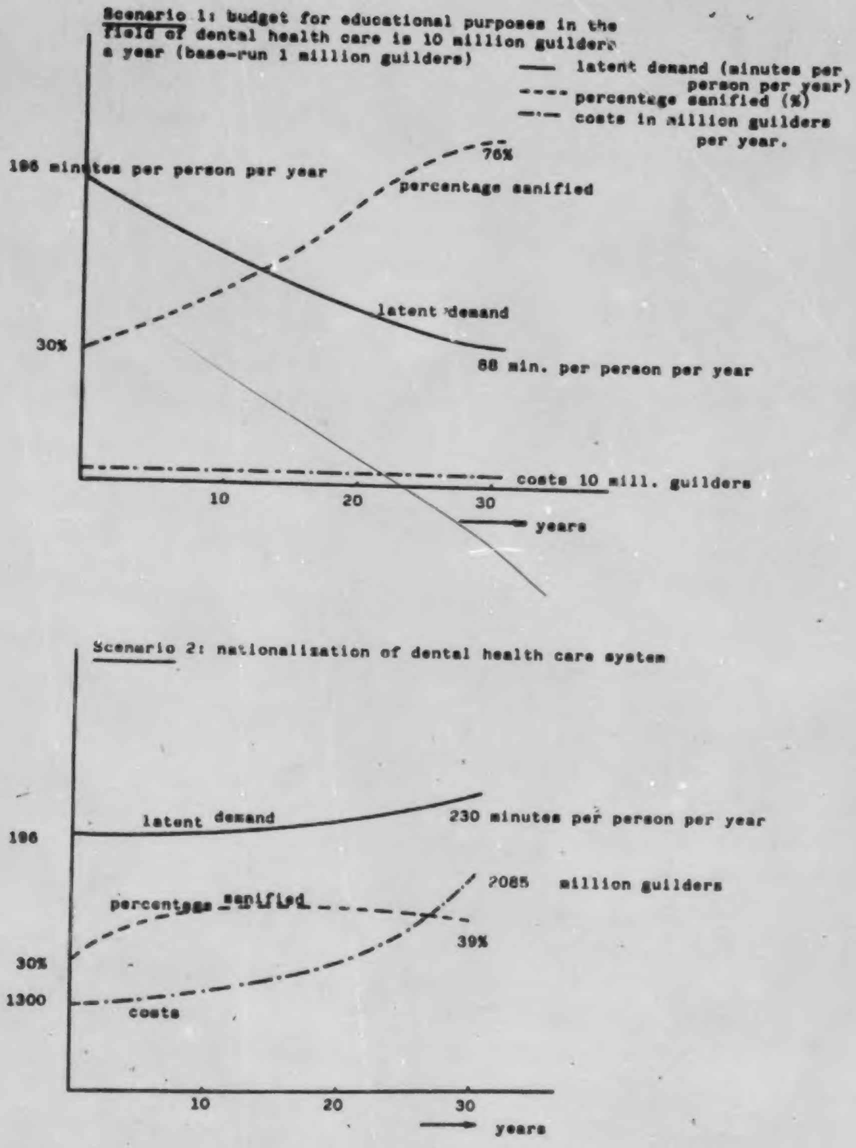


Fig. 4. Two scenario's of DENTIST.

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Appendix:

Concept report of dentist (DENTal) health care system interactive Simulation Tool).

In The Netherlands efficiency and effectiveness of the dental health care system is becoming more and more subject of thorough discussion. Both the government and the consumer organizations dealing with dental health care are insisting on structural improvements.

A simular discussion is carried on by the dental profession. What is lacking in the dental health care organization is a comprehensive approach to care delivery. A better understanding of the most important mechanisms and their effects on the behavior of the system is needed to attain such a comprehensive approach.

An interactive simulation/game is a suitable instrument to transmit an overall picture or gestalt of such a complex social system to a large group of people which is involved in dental health care. The interactive simulation/game also offers the opportunity to the participants to gain experience in managing complex social systems in general.

The interactive simulation/game consists of a simulation model describing supply and demand of dental services. This computer simulation has been embedded in an interactive simulation/game.
Three groups of players are distinguished i.e., the government, assisted by the insurance organizations, the dental profession, and the parliament, which represents the consumer.

The goal of the game is to transfer insights concerning the mechanisms in the dental health care system.
A special feature of the game is the management of the system of dental care by distinct groups each of which have a partial view of and influence on the system.

The interactive simulation/game is aimed at a broad audience, which is professionally engaged in dental health care; administrators, dentists, dental students, and insurance employers.
The size of the group of players wich can participate during a demonstration varies between 6 and 20 participants.

Game-operation requires the presence of necessary hard- and software.
The game-operator(s) have to control man-computer interactions as well as the interactions between the respective groups.

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Some affective outcomes from simulation techniques in secondary education.

Introduction

The use of simulation techniques is no new phenomenon. Such techniques have been in widespread use in areas ranging from aircraft pilot training to management courses. However, their use in education on a large scale is new, growth having taken place mainly in the last ten years or so. This growth raises problems. No new educational approach will be accepted unless it is seen to offer something new or different. Also, while established approaches are often used without question, evaluation is usually demanded for any new approach. School curricula are crowded, and teachers are busy: what, then, do simulation techniques achieve? What can they achieve better than other techniques? Have they any weaknesses?

Research Review

In reviewing the application of simulation techniques, two quite separate strands of research exist. Firstly, there is the educational approach: in this, a wide range of simulation type techniques are employed for supposed cognitive benefits. It is regrettable that very little empirical research has been carried out with these techniques. Secondly, there is the social-psychological approach to attitude change through various forms of simulation, often involving some form of role play. The two areas of research can be summarised:

Educational : Range of simulation type techniques; tends to be philosophical or descriptive; concentrates on feasibility.
Social-psychological : Mainly role play techniques; tends to be empirical; concentrates on attitude measurement.

The main conclusion from the social-psychology research (1-12) is that role play techniques can often bring about large attitude changes; however, these changes are not always larger than those achieved by other techniques. Reasons for the changes are not agreed (see 13:24-29, and 14).

Many papers in the educational literature merely describe particular teaching materials, and how these materials were used with pupils or students. Evaluation rarely goes beyond the observation that the materials "worked", and that enjoyment and increased motivation appeared to occur. Gillespie (15), in a much quoted article, merely describes such feasibility studies. Stadsklev (16) discusses techniques of assessment that are open to serious criticism (see 13:7-20). Shirts (17) comments that "for users, they have high face validity". Bloomer (18), speaking in the context of science and mathematics, concentrates on cognitive aspects.

Wentworth and Lewis (19) comment that simulation techniques are no more effective than other techniques cognitively, while Twelker (20), in a paper that may turn out to be of importance in the long run, gives a hint that transfer of learning may be a possible outcome from the use of simulation techniques. Stopp (21), in a useful survey of the use of simulation techniques in Geography classes in England, notes the extent of the use of such techniques, and points to areas of evaluation which are of interest. Milsen (22), limiting himself to less able pupils, defines criteria for effective materials.

It is recognised that obtaining empirical data in evaluating simulation techniques is a time consuming and frustrating business; however, it is regrettable that so few papers draw attention to actual measurements. In one of such papers, Bilick (9) compared a simulation technique, a lecture, and a passive technique (reading) as methods to achieve attitude change. Results favoured the simulation technique. Matefy and Acksen (23), using rather small samples, did not find advantages for role play over other techniques; however, they made a number of important observations about the effective use of role play. In the work of our own group, three major studies have indicated the power of simulation techniques in developing the attitudes of awareness and appreciation through science education (see 13,24-28).

It is difficult to establish clear cut conclusions. It would appear that simulation type techniques have no overall advantages in achieving cognitive objectives, but that their strength lies in achieving affective or psychomotor objectives. Perhaps the most important observation is that of increased motivation and interest. These seem to be almost universally observed.

Interactivity

A survey of the literature of attitude change and measurement (24) led to the idea of interactivity. This has been discussed in more detail elsewhere (25-26). Interactivity has been described as occurring when the minds of students wrestle with cognitive material relating to an attitude dimension. For example, pupils may, in a school situation, develop attitudes relating to pollution. These will occur arising from social or media pressures. By making pupils handle a pollution problem by means of a simulation exercise, they come to grips with the factual bases behind pollution problems; as a result they may become better equipped to develop informed attitudes. This process of "coming to grips" can be achieved through interactivity.

Interactivity involves very deep levels of involvement, and can be between pupils, between pupil and material, or between pupil and teacher. By their very nature, simulation, gaming, and case study techniques will generate this interactivity. Other techniques, like structured discussions and programmed texts, can also generate interactivity.

It must be stressed that interactivity is not just participation or communication, although it may involve both. Classroom interaction studies consider interpersonal communication. Interaction, as described here, is an internal mental process, in which new cognitive or affective input is made to "bump up against" previously held attitudes. It may be that intraaction is a better word to describe this process.

In an attempt to test the suggestion that attitude change is brought about by means of interaction, teaching materials were written that aimed to bring about interaction in pupils. These new materials took the form of teaching "packages". Each package was short, built to an established syllabus (29), and designed primarily to generate interactivity. The packages used a range of techniques, and involved printed and audiovisual materials. The content of the packages was familiar - the chemistry contained in the syllabus; the format by which the content was presented was novel, and simulation/gaming presentations were often used. The retention of accepted and familiar content aimed to make the packages acceptable to practising teachers, who are constrained by time and examination pressures. The re-shaping of the content, to achieve interactivity, might bring about attitude change as a sort of "bonus".

Evaluation

In considering feasibility, each package was tested with several groups of pupils, and, by means of observation and the use of questionnaires (for pupils and teachers), it was possible to assess whether each package was workable. Where necessary, minor amendments were incorporated. In all, seventeen packages were evaluated in this way.

A large experiment was necessary to attempt to assess educational outcomes. This involved some 1100 school pupils, aged between 14 and 16. The pupils came from the top 40% of the ability range, and were all following the chemistry course to Ordinary Grade. The packages were written to the content of this course (29).

Groups A and C were exposed to five of the packages over a six month period, while groups B and D followed the syllabus in the traditional way. After a gap of one month, all four groups were assessed, the same basic assessment being used for all. It was possible to follow the younger experimental group for a further eight months, during which time they completed three further packages; they were then re-assessed, the same assessment being employed. With this experimental set-up, a wide range of comparisons was possible. Because the samples were quite large - with 1100 pupils in all - it was also interesting to compare the results for boys and girls. The following analyses were carried out:-

(1) Compare Groups A and B : effect of packages on younger pupils;

(2) Compare Groups C and D : effect of packages on older pupils;

(3) Compare Groups B and D : effect of teaching and maturation.

The comparisons provided in (1) and (2) above could themselves be compared, providing some form of experimental replication.

Techniques for evaluation

Any attempt to measure attitudes is fraught with problems. Even defining an attitude is difficult, and a wide range of definitions are discussed in the literature. This wide range of definitions can lead to a wide range of approaches to measurement. Regrettably, there have been few attempts to compare results from different measurement techniques. Because of the inherent difficulties associated with attitude measurement, some writers (30) have argued for a multiple-indicator approach, never relying on only one technique. But, there are further problems with school pupils: firstly, many techniques of assessment are unacceptable in a school situation; and, secondly, with large numbers, paper and pencil tests are the only practicable approach.

Four approaches were used in assessing the packages. A full description is not appropriate here, and is given elsewhere (see 26); a review of all available methods, with critical comment, is available (see 13,24). Three of the four methods were incorporated into an assessment booklet. The fourth method was random interviewing. In this, a sample of the pupils was interviewed as they completed their assessment booklets, the interview being structured to provide evidence relating to the validity of the booklets.

The four methods can be summarised:

(1) Semantic Differential; Increasing

(2) Likert-type questions; Complexity

(3) Situational questions; and

(4) Random Interviewing. Validity

The Semantic Differential technique was a modification of the method described by Osgood (31) in which pupils responded to bipolar word pairs. The Likert-type questions followed the pattern of assessment first put forward by Likert in 1932 (32). This is a versatile and elegant technique, in which pupils expressed opinions on various statements; a modification was used. Situational questions were first developed by Handy and Johnstone (33), and were extended later by Hadden (34). In such questions, a real life situation was simulated, and pupils invited to indicate how they would respond. Such questions were difficult to devise, and to mark, but they can provide very useful insights into pupil attitudes and possible behaviour. In all of the above, the main modification was in the analysis of results. In this, each question was analysed independently using non-parametric statistics. Traditional attitude scaling was rejected for various philosophical and statistical reasons, these reasons being discussed elsewhere (13,24).

Results obtained

The assessment was designed to provide evidence of attitude growth in five main areas:-

(1) Historical Implications of Chemistry;
(2) Domestic (our daily lives) Implications of Chemistry;
(3) Industrial Implications of Chemistry;
(4) Economic Implications of Chemistry;
(5) Socio-moral Implications of Chemistry.

It appeared that successful growth had occurred in four of the above areas, little attitude growth being detectable in the "socio-moral" area. The attitude growth appeared to remain stable with time, at least up to the fifteen month interval. It could be argued that, having taught within these five areas of chemistry, pupils have learned successfully within these areas. However, in previous work (27), Nasr had demonstrated that, at least in the short term, format changes in the presentation of material to be learned altered possible attitude changes quite markedly. It seems that, as far as attitude growth is concerned, simply "teaching attitudes" is inadequate; the correct strategy is more important. The experimentation described here supports the hypothesis that successful attitude growth is brought about by means of interaction, and interaction is achieved through gaming and simulation techniques (among others). Of course, the validity of the measurement requires to be scrutinised, and no doubt many improvements will need to be developed in the future.

It is interesting to note that the fifth area, involving much more personal attitudes, appeared to be largely untouched. Thus, it could be argued that social engineering or brainwashing cannot be achieved readily by means of this simple curricular manipulation. What simulation techniques appear to be able to achieve is the development of cognitively-orientated attitudes. Within education, this type of attitude is of particular importance, and there appear to be few established ways to develop such attitudes successfully. In the past, successful attitude development within a school setting depended on chance factors like a "good" teacher, or a particularly stimulating peer group.

A number of other areas were also touched upon in the assessment. These included a study of pupil attitudes to the use of group discussions in class, an assessment of pupil enjoyment, and a look at the possible occurrence of knowledge integration and transfer of learning. As might be expected, pupil enjoyment in the use of the packages was observed to be very high. Looking at the five main areas of interest covered by the packages, outcomes of knowledge integration and transfer of learning might be expected. This appeared to be the case, although the evidence was insufficient to conclude this with certainty. If further study supported the observations, then a powerful teaching strategy would be demonstrated.

Conclusions

It was remarked at the beginning that, in the use of simulation type techniques in education, the emphasis tended to be on cognitive outcomes. Most evaluation focussed on the important practical issues of feasibility, often neglecting the measurement of educational outcomes. While these trends are understandable, this paper seeks to emphasise the importance of non-cognitive outcomes arising from the use of such techniques; indeed, it has been argued that such non-cognitive outcomes are the most important ones, mainly because other teaching strategies do not seem to be so successful in achieving them.

In attempting to devise successful ways to develop pupil attitudes relating to an established curriculum, simulation and gaming techniques have been used as a research tool. In this, a number of helpful "lessons" have emerged, and these may be useful in directing the efforts of future writers, so that, hopefully, their materials will prove to be effective in achieving educational goals. Five main "lessons" are suggested:

(1) For the widespread use of simulation techniques, write to an established syllabus (or course) for a clearly defined population. The set of chemistry packages used in the main experimentation turned out to be extremely marketable, not only within Scotland and the remainder of the U.K., but also in a large number of other countries. This marketability probably depended on the established content of the packages, more than any belief in the usefulness of simulation type techniques.

(2) Aim at brevity and simplicity. Time is precious in educational establishments, and many otherwise good materials

may be ignored if they prove too time consuming or complex to use.

(3) Where possible, try to evaluate. Evaluation is more than a study of feasibility, although this is important. Although time consuming, difficult, and often frustrating, empirical measurement provides data which guide the most effective use for such materials.

(4) Avoid making too many claims of a cognitive nature about a simulation type material; it appears that, compared to other teaching strategies, cognitive advantages for simulations are not very marked. By contrast, remember that non-cognitive outcomes may be far more significant.

(5) Try to integrate simulation approaches into a total teaching strategy, using such approaches for their strengths, complementing other approaches which have different strengths.

Acknowledgement

Appreciation is expressed to the Scottish Education Department for financial assistance with much of the work described.

Appendix

Interactive teaching packages.

(1) The Protein Problem - a look at the world protein problem;
(2) Chemistry in our Lives - how chemistry affects our lives today;
(3) The Energy Problem - planning an energy programme for the future;
(4) Energy for the Future - a possible hydrogen-methanol economy;
(5) Choosing an Anaesthetic - re-living the discovery of halothane;
(6) The Sulphuric Acid Story - production planning, past and present;
(7) Isotopes - production, use and abuse;
(7B) Isotopes in Our Lives - a more advanced version of (7);
(8) The Fertiliser Problem - designing a compound fertiliser;
(9) A Problem for the Chemist - Nitrogen Flixation, past, present, and future;
(10) Take Your Choice - Selecting polymers by market requirements;
(11) What is an Explosive? - Combustion, explosions, and Nobel;
(12) Focus on Lead - extraction, purification, and social contribution;
(13) Polar or Electrovalent? - the place of scientific experimentation;
(14) The Amsyn Problem - simulation of a common industrial dilemma;
(15) Magnesium from the Sea - designing a successful extraction process;
(17) Elements in the Earth - patterns and periodicity.

Notes

The packages were written to the criterion of interactivity; many, but not all, use simulation or gaming techniques to achieve this interactivity. Other ranges of packages exist, in science, biology, and university chemistry. The above range is distributed from: The Scottish Council For Educational Technology, Dowanhill, Glasgow, SCOTLAND.

3.6. Drs. C. Teyken, Educational Department, Teacher Training Institute Ubbo Emmius, Leeuwarden, The Netherlands.

How to build a Simulation / Game on problem solving skills?

1.0 When some years ago I entered upon the territory, which appeared to be called "simulation and gaming" my first reaction was one of surprise. This surprise was mainly caused by the fact that this territory seemed to have such a different character form the territory in which I had chosen to work. Not only did one quote form different sources and cultivate a very special language; one also had one's special history and one posed scientific questions, which at first sight seemed to have little in common with the territory of educational psychology.

Within the territory of educational psychology the "theory of teaching" forms an important part. This theory is centered round a number of problems which have to do with teaching in its general sense. We are here trying to answer those questions which have to do with:

- the formulation of objectives
- selection and sequencing of subject matter
- the choice of strategies and tactics
- the development of instruments for evaluation and so on

In short: the description - analysis and planning of teaching-learning situations and curricula. Although the notion of teaching-learning situations comprises a large variety of phenomena the development of a theory of teaching and learning in Europe has to a large extent been aimed at the transmission and application of knowledge.

This orientation can be straightaway explained from the reproductive nature of education. The more productive forms of education deserve relatively little attention. In the literature of teaching we connected with these productive forms of education concepts like:

- art education
- process education
- heuristic teaching creative problem solving
- discovery learning and
- .... simulation and gaming.

These concepts seem to call forth a diversity of educational forms which cannot be reduced to a common denominator.

An analysis of the publications (Teyken, 1979), in which these concepts are used, shows that this diversity concerns especially the "surface-structure" of education. The concepts under consideration represent a number of educational forms which show an analogous "deep-structure". This structure can be described in the following way:

. a problem is posed
. a process of solution is started in which certain
  skills are used
. a solution is evolved or solutions are evolved.

From the literature which has been published on the subject of discovery learning it will become clear that this "deep-structure" is not only used for the development of problem solving skills, but also for the acquisition of fundamental principles, generalizations, concepts in certain subject areas. In the first process approach the full emphasis is on the process; in the second approach more attention is paid to the products of the process. Wittrock (1966) characterizes these process approaches in the following way:

"The learning of heuristics of discovery and the learning of rules or generalizations within subject fields".

In the first process approach the process in problem solving is the first aim: the emphasis is on the development of certain skills and techniques. In the second process approach the process of problem solving is used as an instrument for the acquisition of knowledge: of course certain skills are presupposed. They have, however, a purely instrumental function. In this introduction I restrict myself to the first approach, because the discussion about the effectiveness of simulation games tends to go in the direction of the development of cognitive or problem solving skills.

2.0 If we base ourselves on the discussion about the effectiveness of simulation games we can say that simulation games in general are developed to realise objectives within the cognitive and affective domain. The simulation games which belong to the cognitive domain, mainly concern the acquisition and comprehension and application of new knowledge. The simulation games which because of their objectives belong to the affective domain are usually aimed at influencing attitudes or at creating classroom conditions that are conductive to attitudinal change. (Orbach, 1977)

Research on the effectiveness of simulation games also suggests that these games are not more effective than other forms when transmission and application of knowledge are concerned. (Garvey 1971; Fletcher, 1971; Livingston/Stoll, 1973)
It is likely that simulation games are effective in influencing opinions and attitudes. Also it is emphasised again and again that simulation games stimulate motivation. With the research on human problem solving in mind this effect can be generalised to other ways of problem oriented teaching like: project teaching - discovery learning and so on.

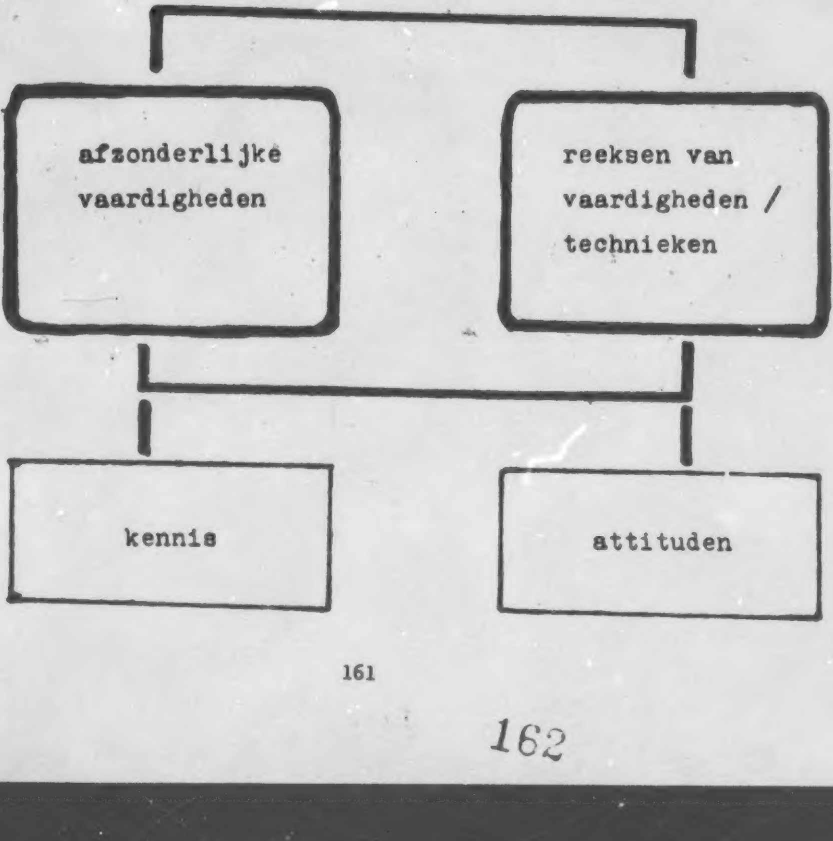
Because of these results Suddaby (1976), Mc. Guire (1976) and others expressed the hypothesis that simulation games may be of value in the learning of higher order cognitive skills.
However, for this hypothesis there is little empirical support (Van Sickle, 1978).

3.0 As I have said in the introduction the usual educational theory development does not warrant the development of simulation games which are oriented towards problem solving.
But influenced by research on the psychology of creativity and the psychology of thinking in America and Russia, and a number of Western European countries a new orientation in educational thinking appears. It is especially the cognitive impact of this research which is important. As far as publications on cognitive processes are concerned it would seem that of late years an exponential growth has taken place.

Based on these recent developments we can describe a number of propositions for an educational theory of problem solving behavior.

The concept of "problem solving behavior" is at the centre of this theory. The concept comprises both independent skills (like analysis-synthesis-evaluation and so on) and sequences of skills. Problem solving techniques like the brainstorm method and the matrix-method can be seen as belonging to this category.
A technique of producing ideas like the brainstorm method consists of a number of skills (producing ideas; combining ideas; evaluating ideas and so on), which are interconnected on the basis of some heuristic principles (the ability to postpone judgment; the ability to produce ideas fast).

PROBLEEMOPLOSSEND HANDELEN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attituden

The operationalization of the concept of problem solving behavior in terms of cognitive skills has some obvious advantages.

One of the most striking advantages is formed by the fact that the number of cognitive skills is limited. With the help of a relatively limited number of skills the immense variety of problems can be reduced. In the literature of educational psychology a great many classifications of skills have been published.

Most of these classifications, however, show little consistency and have hardly any empirical foundation. The classifications of Bloom (1956), Lompscher (1972) and Guilford/Hoepfner (1971) are exceptions.

- Bloom:
  - analysis - synthesis - evaluation

- Lompscher:
  - breaking up a whole into its components;
  - assessing the qualities of a whole;
  - comparing an object or situation as regards differences and similarities;
  - arranging an object or situation with the help of one or more criteria;
  - abstracting;
  - generalizing;
  - classifying;
  - specifying.

In their publication "The analysis of intelligence", Guilford/Hoepfner describe the following six skills, which play an important part in problem solving behavior:

a. thinking rapidly of several characteristics of a given object or situation;
b. classifying objects or ideas;
c. perceiving relationships;
d. thinking of alternative outcomes;
e. listening characteristics of a goal;
f. producing logical solutions.

The aim of a theory of problem solving behavior can be described as the optimalization of this behavior. In general outline 3 strategies of teaching can be distinghuished:

. Firstly this behavior can be influenced by the transmission of KNOWLEDGE. The knowledge may concern the various types of problems; or the processes which take place when solving problems or the solution resp. solutions in which the processes result. What is meant here is especially knowledge which is psychological or methodological in nature. One cannot only expect pupils to distinguish notions like open and closed problems and hypotheses, one should also expect them to be familiar with problem solving strategies; to be able to recognize steps in their own problem solving and to be able to reproduce and apply certain heuristic principles, such as combining ideas in a systematic way.

. The second strategy of optimalization is the training of problem solving skills such as analyzing problem situations and problem solving techniques like brainstorming.
According to the hypotheses of Suddaby (1976) and others simulation/games are especially useful within this strategy.

Using the simulation game like this presupposes that one does not see the simulation game as a separate entity, but as a teaching situation in a sequence of teaching situations. The simulation game is part of the whole curriculum.

This view tallies with the idea that problem solving behavior should lead to transfer to daily life situations.
Transfer can be stimulated by the use of simulation games as an intermediary between the ordinary teaching situations and daily life situations (Orbach, 1977, p.350).

'ordinirary' teaching-learning situations	simulation games as teaching-learning situations	'daily-life' situations
(1)	(2)	(3)

. A third strategy of optimalization is influencing attitudes. The most important attitudes concerned here are:
- a willingness to experiment/to take risks - and accept uncertainties and doubts;
- a willingness to tackle problems in a systematic way;
- the ability to postpone judgement and so on.

4.0 Reproductive and productive teaching situations.

When dealing with the second strategy of optimalization I said that simulation games should fill an intermediary function between the more usual teaching situations and daily life situations. These situations are distinguished by a gradual increase in complexity (Orbach, 1977, p.349). The development of teaching-learning situations, that show this increase in complexity, requires:

- that we can give a description of teaching-learning situations on the basis of objectives.

- that we can name various variables which cause the grades of complexity.

A description of teaching-learning situations can be based on the distinction between reproductive and productive forms of education. In the reproductive forms of education we have to do with the acquisition and application of knowledge. The productive forms are characterised by the "problem-process-solution structure". This structure can either be used for the acquisition of fundamental components of knowledge such as concepts, principles, models, and so on regarding a certain subject area, or, for the development of problem solving skills. Because in this teaching-learning situation problems and skills dominate as components; and because there is a strong interdependence between the type of problems and the type of processes, it is useful to refine this category with the help of a classification of problems.
Since the early sixties a number of classifications of problems have appeared in American and European literature, which might partly function as such (Teyken, 1979).
The classification of problems, which was developed by Dörner following from the classifications developed by Reitman (1965) and Lüer (1973) suits our purpose best.

- the classification comprises a number of categories, which are current both in the psychology of creativity and the psychology of thinking, and in the practice of teaching.

- the classification shows a substantial and a behavioral dimension. The formal character of the substantial dimension allows the classification to be applied to a large number of subject areas and areas or learning.
  Within the behavioral dimension the various aspects of problem solving behavior can be given a place.

We speak of a problem or a problem situation when an individual is faced with a situation which seems to him unsatisfactory and if he tries to realize a situation which to him seems more satisfactory. In other words we have to do with a problem when there is a discrepancy between an undesirable starting situation and a desired final situation.

-problem-

Regarding the starting situation and the final situation Dörner distinguishes between the openness and closedness of a problem. The starting situation of a problem is themore open in character the more possibilities the problem solver has at his disposal to tackle the problem. So we can say that the openness of the starting situation forms a special difficulty. The aspect of choice is in fact an added problem, which has to be solved first.

On the reproductive level pupils are confronted with problems which they can solve purely from memory or by making use of books or other external sources of information; on the productive level pupils meet problems for which they need cognitive skills like comparing, classifying, analyzing and so on. It goes without saying that the reproduction of knowledge is needed in applying these skills. In the application of these skills on a certain body of information something "new" is created. This "new thing" can be the formulation of a principle or a relation and so on; or it can be the development of a model or a procedure and so on.
The advantage of classifying problems like this, is that, the more elementary forms of problem solving which require purely reproductive knowledge (and which according to some people do not even deserve the predicate of 'problem solving'), are brought together in one theoretical framework with the more complex forms of problem solving.

From research that has been done after the difficulty of problems it becomes clear this is not only dependent on the supposed skill or skills, but also on factors like "information". The extent and organization of information appear to correspond especially with the difficulty of the problem. Finally the amount of preparation and the required knowledge and skills are important. Based on these considerations we can distinguish the following teaching-learning situations:

- Reproductive teaching-learning situations:

  include problems (also in the form of themes and assignments), which appeal to only reproduction of knowledge. Here we can distinguish between problems which require the reproduction of facts, relations, concepts and so on and problems which can only be solved by the reproduction of models, strategies, theories and so on.

. Productive teaching-learning stituations:

are centered round problems which require the problem-solver to apply one or more skills or techniques. And to reproduce knowledge from one or more subject areas. In general outline we can distinguish three teaching-learning situations:

a. situations in which problems demand one specific skill and knowledge from one subject area.
b. situations in which problems demand a variety of skills and knowledge from one subject area.
c. situations in which problems demand a variety of skills and knowledge derived from a variety of subject areas. This type of situation is nearest to simulation games.

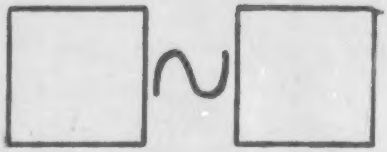
Simulation games as part of the curriculum.

An effective use of simulation games aimed at developing problem solving skills and techniques, presupposes that simulation games are, as a matter of principle seen as part of the curriculum for a certain subject area or learning area. For the development of problem solving behavior does not first and foremost imply the development of NEW skills, but rather the identification of problems or problem situations to which certain skills can be applied; combining skills which in previous teaching learning situations were trained

This difficulty does not occur in problems which are distinguished by a closed starting situation and which therefore allow of only one approach.
Most of the problems which are used in education probably belong to this category. (Van Westrhenen, 1977/ Bauer, 1978). The final situation is the more open in character, the greater the number of possible solutions is. In the research on creativity many problems are used which belong to the latter category. The following problem gives a good example:

"Design at least three visual symbols which visualize the concept 'heavy'.
The pictures should be as simple as possible and no words may be used".

The combination of the criteria of openess and closedness regarding the starting situation and the final situation results in the following types of problems:



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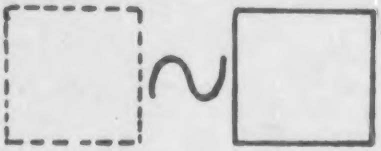

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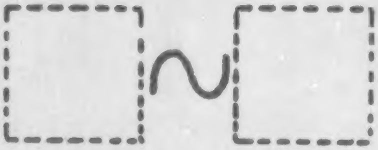

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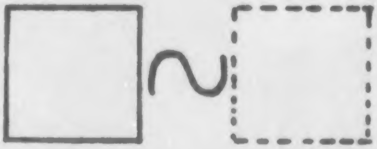

closed - open

These 4 types of problems, which give a formal specification of the substantial dimension, can be combinded with a behavioral dimension. Such a combination is meaningful because in a theory of problem solving behavior the crucial question is:

By means of what problems can we develop what aspects of problem solving behavior?

This idea can be realised by coupling the distinction into reproductive and productive forms of education to the 4 types of problems. In fact this distinction refers to two behavioral levels.

types of problems **behavioral levels**	**O/O**	**C/C**	**O/C**	**C/O**
. **REPRODUCTIVE**				
. **PRODUCTIVE** **autonome skills**				
sequences of skills and techniques				

separately; the training of skills so that a higher behavioral level is reached.
This point of view implies for the development of simulation games:

- that one has to decide which problems pupils have to be able to solve concerning "daily life situations". This means for the curriculum that one has to take the following steps:
  1. to decide on relevant problems
  2. to decide on relevant skills
  3. to decide which knowledge is required.

Prerequisites of simulation games.

An adequate positioning of simulation games in a sequence of teaching learning situations makes it necessary that we formulate the desired behavior and that the prerequisites are known. The prerequisites of simulation games can be determined by "task-analyses" (Sanderson, 1979, p.21).
Such analyses lead to a specification of the fundamental psychological processes which are necessary in the solving of problems. These processes can be described in terms of attention, concentration, perception, long and short term memory and on knowledge and skills assumed to be in the learning repertoire (Glaser, 1976, p.306)"Psychological analysis of complex tasks is not a totally new idea. Task analyses are performed, although not usually under that name, in virtually all psychological investigations of cognitive activity. Whenever performances are analyzed into components, for experimental, interpretive or theoretical purposes, task analysis of some kind is involved" (Resnick, 1976, p.51).

Especially under the influence of "the information processing approach" a trend has developed in present-day psychology, which, in contrast to the older psychology of testing and learning, pays ample attention to the analysis and description of complex problems.

According to Greeno such an analysis can in general outline fulfil 3 functions: "First, it aids in the design and evaluation of curriculum materials.
Second, it constitutes useful knowledge for teachers who have the task of training students in the skills and understanding that are represented in the theoretical analysis.
Third, it probably would constitute useful information for students who have the task of acquiring the skills and understanding represented in the analysis" (Greeno, 1976, p.158).

Feedback on simulation games.

The empirical research in the acquisition, comprehension and application of knowledge through simulation games and the research wich has been done in problem solving both by the psychology of thinking and by the psychology of creativity gives sufficient support to the thesis that the effectiveness of simulation games which aim at the development of problem solving skills are largely dependent on feedback.
This feedback can be given during and after the process.

The Caribou Hunting Game is a good example of a simulation game that is at various moments interrupted, in order that the participants can evaluate their performance and strategies. De Sickle suggests that these moments of evaluation are structured by the use of checklists, questionnaires and so on.

For the optimalization of problem solving behavior through simulation games it is important that feedback is given not only during and after the process, but also that it concerns both the substantial and behavioral aspects. In other words: the problem solver should receive feedback on the process and on the product.

Because the products of problem solving processes usually get more than ample attention, we will conclude this part with a number of feedback questions which concern the process:

- *was the information on the problem analysed systematic and in detail?*
- *did the analysis of the problem result in a clear description of the problem?*
- *did you collect supplementary information on the basis of the analysis of the problem?*
- *did you develop and consider a variety of approaches based on your analysis of the problem?*
- *and so on ....*

The importance of process oriented knowledge.

Simulation games which are centered round the development of problem solving skills presuppose the reproduction of knowledge. This knowledge need not only concern a certain subject, but i can also concern the psychological aspect of the process of problem solving.

In the research on problem solving the emphasis is laid on the training of problem solving skills and learning to handle problem solving strategies. Although both these approaches imply process oriented knowledge the importance of this knowledge has for a long time been underestimated. The rise of cognitive psychology changed this.

Greeno, Norman and others have in recent publications and independently form each other touched upon the importance of such knowledge. Greeno (... p 108) says that knowledge of cognitive processes: "..... probably would constitute useful information for students". Norman says: ..."if a child knows how to learn, then he can get the knowledge by himself ... and he asks, Why do we not attempt to teach some basic cognitive skills such as how to organize one's knowledge, how to learn, how to solve problems......" (1973, p.000). However, they limit themselves to these general statements and do not indicate what knowledge is relevant and how this knowledge is to be acquired. We might think of:

- knowledge of certain types of problems;
- knowledge of the various steps in processes of problem solving;
- knowledge of the part that cognitive skills play in those steps;

- knowledge of the importance of affective and intuitive; factors in processes of problem solving;
- knowledge of heuristic principles and strategies.

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Metagaming: a game design index approach.

If you have looked at the growth that has occurred in the gaming/simulation area over the past 10 years, (just in the number of new games which are designed and played) you will be very suprised. As the edited compendiums of gaming/simulations[1] attest, the number of gaming simulations is very large. If you are trying to choose a gaming/simulation for a specific purpose you will find it challenging to read about them and almost impossible to play them all. If however, you want to design your own gaming/simulation, you may find the models from other games a helpful start.

We have noted that the game designers who have the most success with building new games are those who have years of experience with playing, designing, and testing games. Over the past four years we have worked with some of these successful game designers: Richard Duke, Allen Feldt, Layman Allen, Nancy Stieber, Peter Smit, Fred Goodman, Robert Cary and others. We have found that Richard Duke has done an excellent job documenting the methodology which he and students use in designing a game[2]. We have built upon this base, and offer some additional thinking in making a game design process available for neophyte designers.

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Most of the work in game design process has been done in the area of defining the problem and exploring the components of the system that will be modeled in the game.
We have found that there is one vital reference system that has not been documented and we think would make game design easier for a neophyte. Therefore we have created a reference which we call a Game Design Index for people to use at the point where they have decided what issues and underlying conceptual problems will be in their game.

To explain what we mean by a Game Design Index, we want to relate a dialogue which we have heard over and over again each time that we have worked with game design experts (i.e., Feldt, Duke, Goodman, etc.). As these experts work on new games it seems that they are always comparing the new problems to ones that they have had similar experiences with in the past and that new solutions often seem to arrive as a building process layered on these past experiences. For example, Feldt would say, ...Dick, do you remember in x problem that we used x gaming mechanism to relay the gestalt? Dick: "Yes, but this situation differs in these ways, 1, 2, 3 -- so therefore I think we can start with this gaming mechanism you mentioned but modify it like this....". This dialogue represents the information that is sometimes referred to as the "game designers' repertoire", and actually is the accumulated knowledge and experience built up over many years.

In order to put this Game Design Index together, we have designed a Wuestionnaire (See Appendix A) to interview expert game designers about the games they have designed. This questionnaire is quite extensive. It has eleven sections broken down into model, scenario, rules, steps of play, events, decision structure, and learning principles.

Each section asks for the issue/conceptual problem or situation and the gaming mechanism used for each game component. These answers from the questionnaire are then loaded into the Game Design Index.

Before showing you the Game Design Index, we will describe the game design process or whole context into which the Index fits.

Define the problem.

As a beginning game designer there are two stages which are important:

a) the practical constraints of the project itself (i.e., the number of people who will play the game, the age of the players, the education level, the time constraints, the equipment available, funding allocated to the project, etc.), and;
b) the issues/conceptual problems/situation that you want to communicate with the game.

Richard Duke has systematized these two sets of information with a set of questions called Specifications for Design and Concept Report (see Appendix B). It is imperative for you to address both of these sets of information as rigorously as possible in order to design a game that does what you intend for it to do. In the physical design areas this stage of the design is known as programming.

There are numerous techniques for exploring the parameters of the problem. Some of these include snow cards, brainstorming, literature research, questioning experts, synectics, systems analysis, and many others. There are numerous books which aid a person in creative thinking techniques, especially in the physical design areas.

This step of defining the problem will lead to the model which will become the backbone of the game. Therefore spend as much time as you need to fully explore the problem. Very often it is the way that one approaches the problem and how one sees it that leads to new insights and clear models.

Organizing the model.

Now that you have defined the problem and have all of the bits and pieces of information that you think you will need, it is time to organize it. We have used numerous techniques for this as follows:

1. Flow Chart of the system.
2. Three dimensional construct (styrofoam spheres and pipe-cleaners to represent the components in the system and the flows between them).
3. Table of contents.
4. Conceptual map or radiating wheel.
5. Matrix of identify the most important objects and attributes of the system.

Before you have decided on the exact model for the game you may try several of these techniques several times. However, eventually you will be able to make a selection of the components in the system which you feel are essential to convey in the game. Also you will be able to identify the decision points and linkages in the system that you are simulating. These points will become essential to the flow of the game. Participants will interact with the model at these decision points. This is where the greatest learning often occurs.

Game Design Index: Alternative Generation.

The Game Design Index is used when conceptual problems are defined, important issues are listed, and ways to translate these ideas into gaming language are being explored. Using the Index, match your issues/conceptual problems/situation with an issue/conceptual problem/situation that has been identified before in an existing game. Check for the type of mechanisms and game components which have been used before to illustrate this issue/conceptual problem/situation in the game. Link the mechanisms in a sequence according to the decision structure you are building in the game. We think that the new designer will find that certain issues and especially conceptual problems have been addressed before and that having a starting point for identifying useful mechanisms will be helpful.

The following is an example of the Game Design Index which has been loaded with the Hex Game designed by Professor Richard D. Duke with a class of graduate students. The format is a three column listing of

1) Issues/Conceptual Problems/Situation (the what);
2) Gaming Mechanism (the how in the game);
3) Game Component (where in the game).

At the end of the Index we have included definitions of the game components (where in the game).

Gaming Concept Report.

After you have decided what to game, and have identified potential gaming mechanisms and components from the Index, you will be able to write a concept report.

The concept report describes the game's model, its components and linkages, and the ideas you have about the translation of this model into a gaming language (i.e., scenario, roles, steps of play, events, accounting system, etc.). It is a document of the new game which can serve as a contract between you and your client. It also furnishes an evaluation criteria that should be used at the end of the testing of the game itself.

In order to organize the concept report, the same format that was used for the Game Design Index can be used.
However, the Index is in an abbreviated reference form and your concept report should include detailed descriptions of the information that you have gathered.

Game Construction and Evaluation.

Now that you have completed the programming stage of the gaming/simulation, the actual fun of construction begins. We have found that the "creative process", or "art of design" is actually much more fun and exciting when the design programming has been done carefully. Also we hypothesize that the "repertoire of techniques" represented in the Index will substantially lessen the amount of trial and error and reduce anxiety for the neophyte designer.

The game design itself will need to go through a number of stages in testing. Usually the calibration of the accounting system and the amount of information that players have to synthesize in the game needs to be adjusted and re-adjusted. This is done by playing the game with increasingly sophisticated audiences until the game runs smoothly with the intended audience.

At this stage you can return to the initial design goals that you set in the form of

a) the specifications, and
b) the concept report.

If the game meets these criteria and the results of the game runs foster communication between participants, you probably have a well designed game.

GAME DESIGN INDEX.

by Jo Hasell and Roger D. Moore.

Analysis of: the Human Settlement Management Game (HEX)

Game Description.

The HEX Gaming/Simulation conveys the resource allocation, communication, and policy making dilemmas in third world countries. The game models thet interactions between food, infrastructure (including energy), commodities, services, and housing resources as well as the different perceptions, actions, and intensity of interactions that occur at different governmental levels. The game is a motivation and consciousness raising tool designed by Professor Richard D. Duke and a group of students at the University of Michigan. The game's client was U.N.E.S.C.O. and the audience was a group of professional planners meeting at a conference in Ghana, Africa in 1976.

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
Need to orient the game participants -- include the following: a. orientation -purpose, history, client, and background b. communication between three levels of government (national, regional and local)	Brief game operator introduction and description	scenario

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
c. show effects of scarce resources in a third world country d. describe game symbols, paraphernalia, and accounting charts and forms e. describe functional purpose of each role and its goals, steps of play and forms f. state rules of the game		
Coordination of actions and communication between three levels of decision makers (national ministers, regional managers, and local settlement managers in a developing country)	Board layout (three levels)-- symbolizes organizational separation of the three levels of government (boards stacked vertically 18 inches apart; local settlement managers sit on the floor, regional managers sit in chairs and national ministers stand around boards)	Roles

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
Management of scarce but essential resources in a developing country by national ministers, regional managers and local settlement managers	Functional definition of role according to level of government -- color coded by gov't level (national -- blue; regional -- yellow; and local-- green)	Roles
Quality of life (modeled in terms of food, housing, infrastructure, services, and commodities provided for the population)	Local level accounting form filled out by local settlement managers	Accounting system
	Indicators chart which tallies the quality of life from all local settlements -- done by game operator and banker for all game participants to see	

Issues/Conceptual Problems/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
National government stability determined by provision and delivery of basic human needs to the total population of the country	Instability blocks-- vertical stack of blocks on national level of the game board-- if stack is too high and topples this symbolizes the overthrow of the national government Verbal reports by the three levels of managers at the end of each game round	Accounting System
Man-made law-- physically seperated local settlements must trade in the regional marketplace	Game operator states rule verbally	Rules
Man-made law-- in a barter economy money has value only on the regional, national and international levels of trade	Game operator states rule verbally	Rules

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
Man-made law-- only the national government can have transactions with the bank	Game operator states rule verbally	Rules
Game convention-- all barter trading starts at a 1:1 ratio	Game operator states rule verbally	Rules
Need to display the game's language for common usage by all participants	Land use-- wall chart Symbols-- wall chart	Paraphernalia
Exogenous occurance which effect change within the country and which must be dealt with as they happen: a. United Nations and development grants- limited amount of outside financial help for developing countries b. migration to and from the outside world is not predictable	Game participants draw event cards when indicated in the steps of play	Event/Pulse

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
c. outside disturbance in a neighboring country such as war, famine, social unrest, and drought d. natural occurances within the country such as fire, flood, famine, and good weather conditions e. inability to influence world money and goods markets -- displayed on international exchange rate chart		
Production, distribution, and consumption of food, infrastructure, housing, services and commodities by the population on a yearly basis	Production matrix determines kind and quantity of production of each local settlement Trade among participants-- redistribution of goods and services	Accounting System

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
	Concumption of some production per game round (all food, services, and commodities and ½ of housing and infrastructure)	
Taxation of production and the pooling of limited resources for coping with large-scale problems	Rules stated on steps of play card	Accounting System
Need to symbolize the goods and services being traded and accounted for in the real world system	Graphic representation by mneumonic symbols of: population-- lego blocks food-- corn pieces housing-- wooden dowels infrastructure-- rocks services-- washers commodities-- shells and money is symbolized by poker chips	Accounting System

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
Need to symbolize local settlement geographic adjacency and land use type in a developing country	Color coded local hexagonal settlements on the game board -- each of the six land uses: agriculture, urban, fishing, mining, savannah, and forest produce one of the five goods and services	Symbols
Natural law-- the constraint of geographic distances limits barter trade between distant settlements	Game operator states rule verbally	Rules
Need to make functional decision points in the game clear for participants	Step of play card for each role in the game-- local steps of play cards have a production matrix on the back of the card displaying kind and	Steps of Play

Issues/Conceptual Problem/Situation (the what)	Gaming Mechanism (the how in the game)	Game Component (where in the game)
	quantity of production for each settlement	

Progress with the development of the index.

To date, the questionnaire has been used to conduct fifteen interviews with experienced designers of games which have physical design components. Some of the games that designers have described include: CLUG, Walrus, Metro Apex, SNUS I, Hex, Urban Dynamics, The Energy Game, Policy Negotiations, Design Games, The Housing Preference Game, The Hospital Design Game, and The Burn Center Design Game. We are in the process of trying to find a simple format to make this Game Design Index accessible and understandable to beginning game designers. We have gone through numerous formats trying to identify a display system which works, and welcome your suggestions and comments. Also we would like to interview you about gaming/simulations which you have designed, especially if they have physical design components.

When we have completed our interviews we will build the Game Design Index. We hypothesize there is a finite number of gaming mechanisms to be systematically listed and described. Likewise, we think there is a finite number of problem frameworks with similarities to new problems. Although gaming problems are different each time, there are similar components in each problem to those previously solved. The Game Design Index will help designers of new games begin to deal with very complex gaming systems by suggesting some solutions to test, to modify and to re-design. This methodology and the Index should be thought of as a guide through a complex process (game design) which makes available solutions that have been used before if appropriate-- and facilitates a springboard effect to new solutions if appropriate. Also each time a new game is designed and new or modified mechanisms are discovered we want to add them to the Index. Thus we see it as a tool which has potential for continued growth and modification.

In order to test the Game Design Index we will be conducting workshops on Game Design. These will vary in length and intensity and will be conducted in an experimental mode to develop and test the Game Design Index for teaching game design. Workshop participants will be taught the design process outlined and will be expected to be able to write a concept report describing a game that addresses a complex physical design problem. Their concept reports will describe the model, roles, rules, accounting system, etc., and gaming mechanisms to be used. The workshop will run 3 days to 10 weeks, depending on the commitment of participants.

The effectiveness measures of this teaching method will be based on the participants' evaluation. Their insight into the game design process, motivation, and knowledge gained and retained of the game's subject matter will determine the processes' usefulness.

APPENDIX A

Gaming/Simulation Questionnaire:

A Tool for Interviewing Expert Game Designers

Model/Simulation.

A model is a representation of a real situation in which only those properties believed to be relevant to the problem being studied are represented (Herbert Simon, The Science of the Artificial).

1 Is there a model (an abstraction of reality) represented in your game? Describe this model. Is the model an actual representation of an existing institution or process or is it fictionalized? What elements of this institution or process does the game abstract? What is the game's underlying concept or problem? Is this concept or problem clearly stated in the scenario, game rules, roles, or elsewhere in the game? What is the stated underlying value orientation of the game?

2 Do the game participants have to know this model to be able to play the game(i.e., model implicit or explicit)? Would knowing the model help the participants play the game? Is learning the way the model operates one or do the participants learn how the model operates?

3 Is there a social/political message implicit/explicit in the game? Is there an image of man implicit/explicit in the game? Does the game have an unstated value orientation or social/political message which is revealed during the course of play?

4 Are functional relations and/or processes represented in your game? If so, what game mechanisms are used to represent/manipulate them? What real-world functional relations or processes are they simulating?

Scenario.

The scenario is an introduction of the problem area or a given "state of the system" and defines the situation presented to the participants at the start of the game. It may be presented in two parts:
1) as a framework for the game as a whole;
2) detail points of reference for individual roles.

The scenario usually includes the historical time of the game, the geographic setting, and the problem and/or issues to be dealt with by the players.

1. Many games start by providing information in the form of a scenario. Does this game have a scenario in the form of written reports, game operator briefing, diagrams, maps, physical models, statistical information and/or financial statements? In any other form? What is the nature of content provided by the scenario? What purpose does it have in the game?

2. In some games it is possible to reload the game with a new scenario from the real-world. Is this possible in your game? How is this done? Before, during, or after the game? Is it possible to reload the game with content from expert judgement? How? If either is possible, what is the nature of the content?

Roles.

Game participants take on roles not necessarily corresponding to those they assume in their real-life situation. Roles should be considered in relation to two aspects:

1) the specific role definitions;

2) how the roles are allocated in the game. Roles may correspond to participants' real-life counterparts or may be an amalgamation of institutional roles and special interest groups.

1. Does your game differentiate players of groups of players by roles? How is this done? Are roles assigned by the game operator? Randomly? What are the roles?

2. How much latitude do you have in playing a role? Are there shared roles in your game? How do you accommodate this? What is the purpose of these shared roles? What are the roles?

3. Are the roles in your game open to interpretation by the players in the game or are they defined strictly for the players by the game role descriptions? How? What is the purpose of the openness (or) strictness?

4. Are some roles in your game deliberately boring or distasteful? How and why is this done? Describe these roles.

5. In your game, are participants required or encouraged to become so involved with their role, through extensive background study before the game run, that they actually "become" the personality of the person being simulated from the real-world situation? What is the purpose of this in the game? What personalities are used?

Accounting system.

The accounting system is a record of the decisions and events together with their consequences, that occur during the play of the game. The display of these changes are often called the indicators and can be used to update the scenario.

1. How are accounts kept in your game? Are there accounting tables? How many variables do you keep account of in the game? Does the operator handle the tables (if used) or do the players?
   Describe the display structure. Does the accounting display record all numbers or just changes over time and/or space?

2. Are indicators displayed for all to see? What is the nature of the content of the accounts?

Symbology/Symbols (Visual Imagery).

Artifacts carefully selected to represent components and linkages of the system in the game, along with the numerical indicators from the accounting system make up the symbology of the game.

1. Does your game use any of the following types of symbols to represent components and linkages in the system? The accounting system?

   a. game board
   b. map
   c. mnemonic or analygous symbols
   d. abstract
   e. symbols of chance
   f. color
   g. size
   h. shape
   i. three dimensional
   j. two dimensional

   Why do you use these and what is the nature of the content that they symbolize?

2. Are physical resources represented and used in the game? What mechanism or device is used in the game to represent/manipulate them? What real-world problem/issue are they modeling?

3. What symbols do you use in the game to represent the accounting system over time and/or space? Are the indicators displayed for all participants to see?

4. Is there a need for players to obtain game symbols in the game to survive or viably function?
   How do you do this in the game? What are these symbols and what do they represent?

Paraphernalia.

Any physical object other than game symbols needed to play the game. Legends, wall charts, maps, pencils, notepads, etc. are examples of game paraphernalia.

1. Is there any paraphernalia in your game that you feel is critical or unique to the operation or intent of your game? What is its purpose and content?

Rules.

Actions or behavior incumbent on game participants, game operator, and the accounting system which must be observed for a viable game run. The rules can be of three types:

1) natural laws (rules) imposed by the forces of the natural world;
2) man-made conditions imposed by the game designer/operator (mechanical and/or norms);
3) partipant controlled changes in the game conditions.

1. All games must conform to some set of natural laws (rules) imposed by nature (i.e., gravity, laws of thermodynamic, etc.). Are there natural laws explicitly stated in your game? What are they? How are they included?

2. Does your game have man-made laws (rules)? Can they be changed by the game operator before and/or during the game run? Can they be changed by the game participants? What is the nature of the content of these rules? What purpose do they serve in the game?

3. Are the same rules available to all players? At the start of the game? During the course of the running of the game? What is the purpose of having all rules available? What is the nature of their content?

4. Are there optional sets of rules designed into the game? Why?

5. In some games the flow of information is one of the major ways for making the game function. Is there secrecy designed into your game? Is there imperfect information? Are there communication restrictions? What are the methods that you use in the game to do this? Information overload? Loopholes? Explicit or implicit? Different information for different players? What is the nature of the content of this information?

Steps of play.

A specific set of activities that a game participant must complete for one iteration or cycle of the game.
Typical steps of play include:

1) a review of the results of the last cycle;
2) an identification of new events or problems and a development of coping strategy;
3) communication with other players;
4) making and recording decisions and transmissions to game operator (putting in accounting system);
5) completion of calculations of the accounting system;
6) recording and displaying indicators (feedback to game participants).

1. In some games players are asked to repeat the same steps of play in a number of cycles. Does your game use this mechanism? How? Why?

2. In some games players proceed through a set of sequential steps which add on information continuously. Does yours do this? How? Why?
   What is the nature of the content of this information?

3. Are the steps of play fixed in your game? Can they be changed? Can the order in which they are played be changed? How does your game allow for this? Why?

4. Is the game sequence fixed explicitly? Implicitly? Are explicit time limits set on certain activities? What mechanical controls are used? Why?

Event or Pulse (Used Synonymously).

A problem, issue, alternative, or piece of information of significant impact in the game to which participants must respond. This usually triggers the exchange of messages and/or generates discussion between participants and usually calls for a quick decision. Although the content of the events are usually determined by the game designer, the timing of their release to game participants is usually at the discretion of the game operator.

1. Are there any events or pulses in your game? If so, how are they introduced into the game? What purpose do they serve? What mechanism or device is used for their introduction into the game?
   What is the nature of their content? Is that content explicit or implied and is this content contained anywhere else in the game?

Decision Structure.

The decision structure is a framework which allows game participants to formulate strategies about how to put together sequences of actions that move concrete situations closer to desired goals.

1. Are there mechanisms in your game, in the rules by which you establish consensus, coalitions, or partnerships? Cooperation? What are these? Is voting used for this? What is the nature of the content?

2. Does your game ask players to identify new linkages between components explicitly in the game? Implicitly? How is this done? Does the game ask players to identify new components? How? Does the game ask players to define a new system? How? What is the nature of the content of this new system/components/linkages?

3. Is there provision in your game for players to be anonymous? How? What is its purpose?

4. Does your game explicitly present players with choices in the form of decision trees? How is this done?

What is its purpose? What is the nature of the content?

5. Does your game predict an alternative future system? How? For what purpose? What is the nature of the content?

6. Does your game provide evaluation of the specific system being played? How? For what purpose? What is the nature of the content?

7. Does your game provide a structure which allows players to identify attributes and/or issues in the game (select not learn)?

8. In some games decisions are made on the basis of chance, cognitive skill and physical and/or some combinations of these. In your game are any decisions made like this? What are they? How is this accomplished? Political/social skills? Affective skills? Psychomotor skills?

9. Does your game generate new policies? How? What is the nature of the content of these new policies?

10. Does your game structure allow for impacts of the system to be identified? How? What is the nature of these impacts?

11. Is there information overload in your game? Is it intentional? Is it unintentional? What mechanisms do you use to do this in your game? What is the nature of the content of this information?

12. Is there a required sequence of events in the game?

Learning principles.

Learning principles are the means by which game participants discover or gain additional knowledge about the system(s) being modeled in the game and the interactions between the model(s) and the participants themselves.

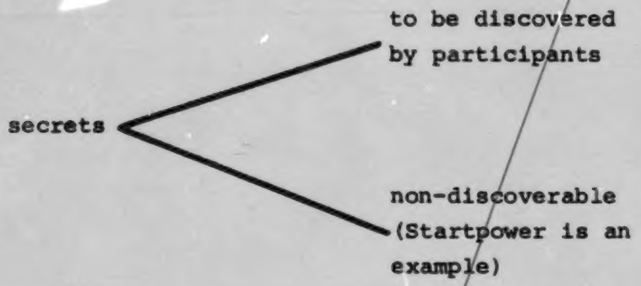
1. In some games all of the information necessary for playing the game is available at the start of the game. The participants must organize, sort, classify, etc. this information for it to become useful to them. In other games information is added as the game progresses. The participants must decide when and how to use this new information or if the new information is of any use to them at all. Does your game use either of these two kinds of methods of information dissemination? If not, how is information given to the participants? If so, does your game use one or both of these methods? What gaming mechanisms are used for this purpose and what is the nature of the content of the information given to the participants by each mechanism?

2. Does your game emphasize

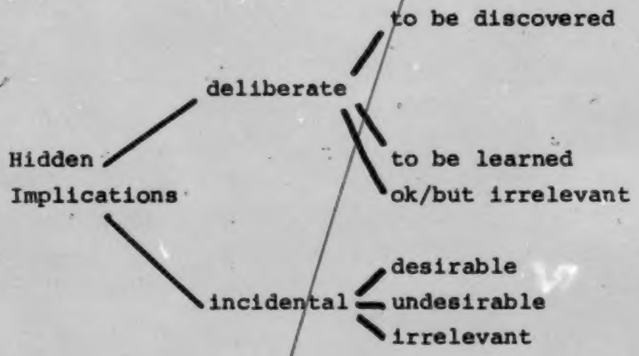
   a. competition
   b. cooperation
   c. both

   among the game participants? How? What mechanisms are used to encourage participants to compete/cooperate?

3. Some games use deliberate secrets as a gaming mechanism. Does your game use lack of information to some of the game roles as one of its mechanisms? If so, what is the nature of the content of these secrets?


secrets
to be discovered by participants
non-discoverable (Startpower is an example)

4. Some games use hidden implications as part of the structure of the game. Does your game do this? If so, what is the nature of the content of these implications?



APPENDIX B

1. Specifications for Game Design

2. Concept Report

Specifications for game design*

1. Problem Statement? Why is a game being considered as a communications device?
2. Who is the responsible client?
3. Who will evaluate the game for completeness?
4. What is the purpose of the game?
5. What is the substantive material to be covered in the game?
6. Game audience? Homogeneous or heterogeneous? Motivation? Size?
7. Context of use?
   - a. Under what conditions will the game normally be used?
   - b. Will it be free-standing or part of a series?
   - c. Or in conjuction with an academic course or training program?
   - d. What follow-up circumstances are anticipated?
   - e. Will the same group run the same exercise repeatedly?
8. Practical constraints.
   - a. What mechanical, political, financial, or other considerations are anticipated relative to constraining the use of the product?
9. Resources.
   - a. What financial resources are available for game design, construction, and testing?
   - b. Is there flexibility to permit alternative designs or cost overruns? How much? Under what circumstances?
   - c. What financial constraints govern the use of the game?
   - d. Is the typical cost of play to be within certain limits?
     What are they?
   - e. How much time is available for game design? Construction? Testing?
   - f. Is evidence of productivity to be demanded? At which stages? What evidence?

g. What are the time constraints during the use of the game?
   May it be discontuous?

h. Will evening or weekend session be a normal operational style?

10.Paraphernalia

a. Are any constraints to be imposed on materials used by the game?

b. Must it be portable? Under what conditions?

c. Are storage requirements to be specified? What are they?

d. What demands for reproducibility are to be specified?

e. Must the kit be standardized materials? What are they?
   Is do-it-yourself reproduction permitted? Required?

f. Are instructions for reproducing the kit to be included?

g. May a computer be used? Which one(s)?

h. What program language(s) are permitted? Required? Must it be batch processed? Run on terminals?

i. What are the limits to computer use in dollars or hours?
   Per cycle? Per run?

11.Media selection.

a. State the reasons for not using other forms of communication (games are generally the most specific and therefore the most costly media).

b. What are the particular characteristics of the message to be conveyed?

c. May other media be employed with the game? Required? Permitted? Under what constraints (duration, timing, frequency, structured or spontaneous).

* Duke, Richard D. Gaming: The Future's Language. New York: Halsted Press Division, 1974. Revised by Jeff Harris and Jo Hasell, 1977.

Concept report for gaming/simulation desing*

1. Define the system.
2. Define the components.
3. Define the roles.
4. Define the component characteristics.
5. Define the linkages.
6. Theme and message transmission.
7. What are the normal game conditions? Typical operation style?
8. Are parallels with particular existing games sought?
9. What style of game is sought? Emphasis on group dynamics or more intellectualized?
10. Is allocation of scarce resources to be central or is a systems gestalt the main emphasis?
11. Is the message to be expressed from a particular philosophy, perspective or jargon?
12. What level of abstraction is desired? Geographic or social scale?
13. What time frame or horizon? What scale of reduction in time?
14. How are power and finances to be conveyed?
15. What level and style of protocols and administrative forms are desired?
16. Are game management skills to be specified?
17. How are players to be organized (groups or individually)? Are coalitions permitted or encouraged? Are multiple roles for one player appropriate?
18. What structure is to be incorporated for issue generation within game play? Predetermined or player generated? Random or preset? Linked under what conditions?
19. Is a physical board to be used? What are constraints of size or complexity?

Concept report and questions cont'd.

20. What degree of player involvement is desired? Emotional or intellectual? Continuous or discontinuous?
21. How is the game room te be staged? Are particular room arrangements or player configurations to be specified? Will constraints to be placed in the room or on pregame activity? Under what conditions will critiques be held?
22. Are particular learning principles to be emphasized?
23. Is an iterative approach required?
24. How many cycles minimum? Are they to grow more complex?
25. How much freedom of movement, rule design, etc., are players to be permitted?
26. Is a scenario to be specified? Are alternative scenarios desired? Is the scenario te be explicit, detailed, highly abstract? Is it to be capable of modification by the players?
27. What is the structure of the symbolic language? Is it to be physical? Three-dimensional?
28. Should its complexity be restricted to permit being learned in a specified time by new players? How are symbols to be displayed during the game? Are maps to be used?
29. Are there any constraints or requirements as to conventional languages or media to be employed (math, stat, Fortran, flow charting)?
30. Are the rules of the game highly rigid, or only partially existent where players are encouraged to develop their own, or to modify a starting set?
31. Are circumstances governing the basic accounting system to be treated differently from rules governing player behavior? How complex is the accounting system? How much time does it require?

32. How lengthy or involved is the list of steps of play? How are they to be presented to the players? Initially, each cycle?

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* Duke, Richard D. Gaming: The Future's Language. New York: Halsted Press Division, 1974. Revised by Jeff Harris and Jo Hasell, 1977.

Definitions.

Scenario	The scenario is an introduction of the problem area or a given "state of the system" and defines the situation presented to the participants at the start of the game. It may be presented in two parts: (1) as a framework for the game as a whole; and (2) detail points of reference for individual roles. The scenario usually includes the historical time of the game, the geographic setting, and the problem and/or issues to be dealt with by the players.
Roles	Game participants take on roles not necessarily corresponding to those they assume in their real-life situation. Roles should be considered in relation to two aspects: (1) the specific role definitions; and (2) how the roles are allocated in the game. Roles may correspond to participants' real-life counterparts or may be an amalgamation of institutional roles and special interest groups.
Accounting system	The accounting system is a record of the decisions and events together with their consequences, that occur during the play of the game. The display of these changes are often called the indicators and can be used to update the scenario.

Symbols (Visual Imagery)	Artifacts carefully selected to represent components and linkages of the system in the game, along with the numerical indicators from the accounting system make up the symbology of the game.
Pharaphernalia	Any physical object other than game symbols needed to play the game. Legends, wall charts, maps, pencils, notepads, etc. are examples of game paraphernalia.
Rules	Actions or behavior incumbent on game participants, game operator, and the accounting system which must be observed for a viable game run. The rules can be of the three types: (1) natural laws (rules) imposed by the forces of the natural world; (2) man-made conditions imposed by the game designer/operator (mechanical and/or norms); and (3) participants controlled changes in the game conditions.
Steps of play	A specific set of activities that a game participant must complete for one iteration or cycle of the game. Typical steps of play include: (1) a review of the results of the last cycle; (2) an identification of new events or problems and a development of coping strategy; (3) communication with other players; (4) making and recording decisions and transmissions to game operator (putting in accounting system); (5) completion of calculations of the accounting system; and (6) recording and displaying indicators (feedback to

	game participants).
Event or pulse	A problem, issue, alternative, or piece of information of significant impact in the game to which participants must respond. This usually triggers the exchange of messages and/or generates discussion between participants and usually calls for a quick decision. Although the content of the events are usually determined by the game designer, the timing of their release to game participants is usually at the discretion of the game operator.

Footnotes

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Interfacing levels of aggregation in games.

1 Introduction

This paper is an attempt to shed some light on one of the most difficult topics in game design: the distinction between and the bringing together of different levels of aggregation. This paper will raise questions rather than report on a full analysis of games with more than one level of aggregation. Perhaps others are looking at the state of the art in this respect more comprehensively (Moore and Hasell, forthcoming). But first let us define or describe some terms.

Simulation games provide participatory models of various particular processes involving more than one party or interest. While the use of simple conceptual models to facilitate discussion of possible courses of action is quite common, the use of this way of thinking for an extended period in a structured way for training or testing is surprisingly scarce. I am sure others at this conference will provide better definitions of gaming or did so in the past (Becker, 1971), but basic elements to most descriptions of simulation gaming are:

- the relation to reality providing a simile still standing outside of some particular part of the present;
- the form which includes people as vital parts of the representation, most commonly groups of people with different positions pertaining to the same process;
- the results, some of which can be used in further play (scores, understanding of the model, familiarity with fellow players) and some of which will be retained (assessment of strategies, understanding of the process being represented, strong and weak points of a particular person in a certain role or position in the model, etc.).

Things like these are often done in any decision-making situation. Someone will say "what if..." and we are outside present reality, imagining ourselves to be in some concerned position and thinking of what the result of some hypothesized process would be for us. And there are by now quite a number of struc-

tured explicit and repeatable simulation games available, commercially or otherwise.
However, the actual use of such long, prepared, shared escapades is still rather scarce. The strong and weak points of gaming have been summarized elsewhere (Smit, 1974) and one of them is the difficulty of designing gaming models that fit well to the need at hand, that is to the subject matter, to the time, cost, and other practical constraints, and to the objectives of the prospective user.

As most conventional teaching and research methods foster specialization rather than a comprehensive approach, games are often used to clarify the total working of a system. To be well suited for that, gaming simulations should both do justice to the specialisation involved and emphasize the more over-all qualities of the system that is being simulated. The underlying gaming models then are likely to encompass more than one level of aggregation. In fact, the interaction between a particular interest and the working of the integral system, or the interface of levels of aggregation as it will be called in this paper, may be of great importance with respect to the quality of the entire simulation.
What is a level of aggregation? One of the early review articles on model design describes levels of aggregation in terms of the difference in perspective between various specialists (Lowry, 1965). Freely interpreted, that review contends that geographers are more interested in the behavior of collectives (e.g. all residents of an area) and in the spatial reflections thereof, while social psychologists are more interested in individual behavior (lower level of aggregation). I should like to add sociologists and town planners on the collective side and architects, contractors, realestate brokers and lawyers on the individual side. While economics is mentioned in that review for its micro-analysis (relatively low level of aggregation) I think it is possibly the first discipline that attempts

to span a bridge between different levels, as macro and regional analysis are well developed branches of that science too. Generally speaking the idea to couple the notion of levels of aggregation to the differentiation of academic disciplines appears questionable to me. Disciplines may change their areas of emphasis as the needs for research and teaching change. Indeed they may split up or integrate quite independently of a concept like aggregation. Thus, without denying the correlation at present, I do not wish to define a level of aggregation by the disciplines that concern themselves with it.

In a general text for the social sciences a level of aggregation is referred to as the degree of complexity and precision (Nataf, 1968).

Levels of aggregation can be compared to units of measurement, that general text continues, and in particular cases the level has to be determined in correspondence with the nature of the questions to be analyzed and of the actions to be undertaken on the basis of the analysis. In practice, however, a compromise has to be found probably between the levels of concern in an action for which policy is being prepared or for which people are being trained on the one hand and the levels on which data can be obtained on the other hand. Often conventions of record keeping and statistics will thus influence the choice of levels to be included in educational or research tools, particularly when quantitative data are essential. However, when behavioral responses are more important, the numbers may be guessed or amalgamated, while the game can be oriented towards one or several levels that correspond to groups or agencies which consitute echelons of decision making regarding the subject at hand. This is the case, for example, in a game about the delivery of material and immaterial aid to victims of World War II and for transmitting the expertise from that service delivery sector to the general public health sector (Webb e.a. 1978). In that instance it was not the figure as such that were of main interest, but rather the institutional responses to a perceived overload, to inequality in service by type of victim and to an entry system that led to the aggravation of some cases.

How else can levels of aggregation in simulation games be described? Well, another application of these games was in the development of theories or hypotheses. The importance of new means to develop theories of multilevel systems is underlined in a book (Mesarovic e.a., 1970). It is contended in that book that a better understanding of such system would strengthen new directions of social research on coordination.

> "Namely, in a properly structured two-levels sytem, the effort needed to achieve the overall goal is divided among the units on different levels, so that no unit is "in charge" of achieving the ultimate goal, yet the goal of each individual unit is such that the overall goal is achieved whenever each unit is functioning properly" (op.cit., p. 33).

The particular multi-level systems, for which the second part of that book attempts to develop a theory, are hierarchical systems. Nevertheless the first part of that book is of interest here since it introduces three dimensions along which levels of hierarchy can be distinguished:

(1) strata or levels of description or abstraction
(2) layers or levels of decision complexity in the system, and
(3) echelons or organization levels.

Let us look at these successively.

Ad.1 Strata are a solution to the dilemma between the desire to describe even a complex system simply, and the need to take a great variety of input-output aspects of a system into account.

> "One describes the system by a family of models each concerned with the behaviour of the system viewed from a different level of abstraction...for such a hierarchical description to be effective it is necessary that the functioning on any level be as independent of the functioning on other levels

as possible" (op.cit., p. 37).

For example, a fully automated production plant may be looked at on a physical level (materials go in and finished products come out), or on an information processing level (signals about the production process go in and control signals come out) or on an economic level (performance data go in and interventions come out).

When thinking of levels of aggregation the use of the term abstraction may be somwhat confusing.

Abstraction may refer either to the perspective approach or description on the one hand or to the mode or form of representation on the other hand. For example, after one has chosen to include in the game a fairly detailed "account" of recources towards decision making, one may design a game that employs plastic chips or glass marbles or some other counters without specifying whether these denote money, time, contacts, good-will or skilled personnel, let alone what conversion rates apply to real dollars hours, quality of personal connections, intensity of positive affiliations, or number of trained employees. Such games, e.g. those of F.L. Goodman (Goodman, 1970; Smit, 1971; Goodman e.a., 1973), will have a low level of abstraction in the conceptual sense (i.e. a low level of aggregation, choice for a detailed depiction of decision making recources) but at the same time they will be highly abstract in their form of representation (i.e. no precise meaning for the symbols used). To avoid this confusion, the term aggregation may be adhered to when the choice as to the level of subject matter or approach is meant. Terms like abstraction, reduction and substitution are then left free for use when it comes to the choice for a form of representation during actual game constitution (Lipschits, 1973). As the distinction of strata, or levels of description depends a lot on the observer, his knowledge and interest, it may in practice come close to the distinction of disciplines or academic fields which was raised before. For teaching-games in a particular field this may be useful, while for games to be used in policy preparation or integration this may or may not be relevant.

Ad.2 Layers, or the second type of hierarchy according to that book (Mesarovic, 1970) are an answer to the dilemma of decision making where one wishes to act without delay on the one hand, while on the other one needs to take time to better understand the situation...

> "Essentially, one defines a family of decision problems whose solution is attempted in a sequential manner, in the sense that the solution of any problem in the sequence determines and fixes some parameters in the subsequent problem so that its solution can be attempted..."
> (op.cit., pp. 43-44).

The selection of decision making levels is based on the recognition of essential functions in the system and probably has to do more with feasible alternatives, availability of comparable data and intervention possibilities rather than with an observer's perspective or a describer's discipline.
This makes these levels of decision making probably more useful for policy preparation and advice but they may or may not be appropriate for teaching games.

Ad.3 Echelons, or the third and last type of hierarchy discussed in that book on hierarchical systems (Mesarovic, 1970) concern levels of organization. In contrast to single level-single goal systems, or single levelmultigoal systems the book emphasizes multilevel, multigoal systems as needing a new theoretical base. The latter are described as follows:

> "...the class of multilevel multigoal systems is characterized by the existence of the hierarchical relation between the decision units of the systems. The existence of a supremal (top level) unit is the principal characteristic of these systems; the decision problem for the supremal unit is a principal problem specific for multilevel systems"

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(op.cit., p. 51).

I wonder if indeed the existence of an unrivaled top unit is essential, and whether multi-headed or partially hierarchical structures could not be counted as members of this class of systems as well. If the requirements for direction to a single non-conflicting set of goals can be relaxed, we are getting close to a description of many of the not-perfectly-hierarchical systems that policy makers and teachers of today are concerned with.

Of course these three types of hierarchy do not stand in isolation. It does not make sense to prepare or make decisions if there is no organization or conflict-reduction-procedure to help implementing these choices. And neither an organization nor a decision can be made without at least an implicit description of the problem. So most complex situations require all three, and simulation games generally deal with complex processes indeed.

Of the three types of hierarchy discussed, all are relevant to the concept of the level of aggregation as it will be used in the rest of this paper. In as much as the first, or the level of description, is termed synonymous with the level of aggregation, it should not be confused with the manner of description, e.g. the degree of precision in game symbols. In as much as the second or the level of decision making, is deemed the same as the level of aggregation, it should not be confused with the choice as to the subject of decision or the content-matter of the game. The third, or the level of organization, finally, seems to be very much parallel to the concept of a level of aggregation in a simulation game particularly when dealing with games about human processes or organization.

A later introduction to the use of quantitative models in planning deals with levels of aggregation and method of categorization under the same heading (Lee, 1973). According to this introduction what constitutes an acceptable level of aggregation depends on two things:

a whether the questions the model is designed to answer can in fact be anwered in terms of aggregated variables;

b whether the real-world relationships can be adequately represented by aggregates (op.cit. p. 21).

The first of these criteria comes close again to the description from the general work for the social sciences discussed earlier.

The second criterion can be even more exacting, as is illustrated in the introduction as follows:

> "However, the second...may mean that it is desirable to disaggregate population into age groups even if we are only interested in total population. This would be the case, for example if the factors which determine the level of population...have different effects on (differ in their rates of incidence for) different age groups. For example...a much higher rate of migration among young adults...affects not only the total population, but also the future structure of the population, because it is this group which produces the most children. A model which failed to disaggregate population into age groups would ignore any relationship of this kind which varies between age groups, and one would therefore have less confidence in its results" (op.cit.p. 21-22).

All of which goes to show that it is important in any kind of model to include the right levels of aggregation.

The discussion on how simulations and games can be right, correct or valid becomes relevant. This is by no means an easy discussion, because games, like all models, are meant to be a simplification and an apparently true representation at the same time. Starting then, with a selection of aspects or attributes of the processes to be represented, it is important to include in a game that level or those levels of aggregation that are essential to these aspects. This selection can be made according to the game designer's personal perspective (games as an expression or art) or corresponding to some purpose the game has to serve (games as an instrument or tool). In an article in a reader on gaming-simulation (Greenblat, 1975) this is explained by one of the editors:

> "Like a book, gaming simulation is an explicit statement of what the designer believes about some reality he (or she) is attempting to simulate. The referent system, you will note, is not "reality" itself but rather a set of theoretical propositions about reality. The process of design entails:
> 1 delineation of the theoretical base,
> 2 construction of a conceptual model of the system, and
> 3 transition of this model into an operating model or simulation" (op.cit. p. 106).

This implies that there are three realms in which a level of aggregation can be important or correct or relevant:

a It is an essential part of the real system (e.g. as understood by advanced specialists or as found to be of most predictive value in preceding studies);

b It is essential to the image of the real system that is to be created (e.g. it links up with the starting level of expected participants and it furthers their understanding); or

c It has actually been included in the gaming-model (and appears to function well within the rest of the game structure or may need some other abstractions, reductions or substitutions to function more adequately).

This has led us to some notions on valid games and approaches to game construction, while we started by looking for descriptions of the concept of aggregation.

Aggregation, this paper contends, has to do either with physical detail, with time perspective, with level of authority, with order of magnitude or with a combination of these. But after all these general descriptions and characteristics it may prove illuminating to look briefly at some examples of levels of aggregation in simulation games.

Not in all gaming models, nor in all other simulation models or scientific theories, are different levels of aggregation dealt with explicitly. Sometimes, the problem of simplifying reality is seen as one of slicing an unstratified cake: once the right level has been determined all the roles and variables are expressed on that level. Take for instance a well-known land use game about urban growth in the U.S. called CLUG (Feldt e.a. 1972). Here all developments (tracts of houses or shopping centers), population (groups of residents or employees), land holdings (cells on a grid-like board) and transportation costs (distance to work and to the terminal for exports) are levelled at a scale of about one mile per section on the board, and time is reduced roughly to an hour per year, money to units of thousands of 1969 dollars, and powers to the secular ones in a single growing town. Influence from lower level processes, such as the deterioration of specific houses or factories, are averaged into probability factors effecting the value of entire sections or board-cells. Influences from higher level decisions, such as the construction of a freeway or national standards for housing, must be introduced by the game moderator as conditions for play or external constraints to be discussed during time-outs only. CLUG, then, is an example of a game in which everything is abstracted, reduced or substituted to fit into the perspective of a single level of aggregation.

Many simulation games, however, deal with processes of which the workings and connections are so varied that need is felt to differentiate and include a number of levels. Take for instance a game about the internal economy and political stability of developing countries, called the HEXAGON game (Duke, e.a. 1977). This game includes three levels at which roles, playing boards and decision constraints are specified. On the lower or township level, the exchange of tools and produce is in the form of barter trade without reserves. On the intermediate or regional level, money can be used and products can be stored.

On the upper or national level, finally, both national and foreign money are used, grants of international aid may be applied for and received, and surplus products are redistributed over regions or sold abroad. Clearly the operations at the different levels are quite different, which may cause some of the misunderstandings producing important dynamics in a political sense. The HEXAGON game is an example then of a simulation game with several, fairly equally developed levels of aggregation.

Games including more than one level of aggregation present to designers the problem of how to integrate these levels into a single operational model. Various kinds of information have to be transmitted between levels as events and decisions from one level will influence the process on another level of scale or time-span or authority or generality. Such transmissions will make one model out of an otherwise unconnected collection of levels and components. Besides, the issue of choosing the right level of aggregation in model design becomes a less pressing one when several levels are included in a well-integrated manner. If some aspect cannot be adequately dealt with on one level there is at least another level or chance to have it included in the overall operation. The better the interaction between levels becomes, the more the levels will support eachother in providing an overall picture of the process being represented.

The following section of this paper will persue some of the ways in which levels of aggregation can be linked to eachother. In section three the question will be explored as to why information between levels is passed on in one way rather than another, in the context of particular types of games. Section four, finally presents some recommendations for further research.

2 Modes of interface

At the point where levels of aggregation meet in complex simulation games, much is revealed to the attentive analyst about the structure of the game and about the underlying hypotheses regarding reality too. These meetingpoints or level-interfaces warrant special attention in game design. Apart from the games that do not have different levels of aggregation operationalized in a manner to be played (e.g. GGS (Van der Mey e.a., 1972), a Dutch version of the CLUG game mentioned before) all simulation games contain some way to link their levels, whether they run parallel to the ways levels are linked in reality, whether they form part of the conceptual model or whether they are just part of the game. Some games almost seem like a series of separate exercises, dealing first with one level of aggregation and then with another without going back (e.g. REPRESENTATION AID-SYSTEM'45 (Webb e.a., 1978) with first the overall aid-delivery system at present, then its general future, then the interest of various interestgroups in it and finally the detailed future-operation of its specific agencies). Other games deal with the different levels that shape reality intermittently, going back and forth several times (e.g. STEREOS (Adviesburo Arnhem, 1971) with activities of development firms and town meetings alternately). Still other games have different levels of concern run simultaneously, side by side during play (e.g. HEHAHO (Van Vught e.a. 1974) with ministries and interdepartmental committees running parallel). Some of the most complicated games have two sets of levels of hierarchy according to which all participants are grouped in play intermittently (e.g. METRO (Tri-Country Regional Planning Commission, 1966) with professional and jurisdictional roles played by the same participants in turn). A second reason why the interface between levels of aggregation warrants further analysis is the fact that the manner or mode in which the interaction from one level to another takes place has its effects on the levels themselves. Often, what is decided in play on one level will count as an objective or a constraint or as a relevant datum on another level. Just how this information will be presented on the latter level depends to a great extent on the way it is carried across from the former. It is often that entities or realms show their nature most clearly at their borderlines.

It is necessary to call special attention to the study of level-interfaces, for at least three factors can be suggested why we tend to turn away from this subject. Firstly, in playing simulation games, one tends to concentrate on one level especially in games in which the participants each remain on one level all the time (e.g. UTRECHTS GRONDGEBRUIKSSPEL (Smit e.a. 1973) with developers remaining developers even when taking part in city council meetings and city officials thinking of the entire town even during development and construction phases). Secondly if one notices the information from another level as such, one tends to notice the content-matter and not the form of presentation or mode of transmission (e.g. in HEETEN (Hoedemaker, 1976) one concentrates on the numbers of new housing units allocated and not on the fact that these are transmitted by people (representatives) and not by letter of decree). Thirdly, the general drive towards simplification in simulation, causes participants and designers alike to overlook an apparent detail like the mode or medium deployed for such particular information as that between level of aggregation. In fact, this ignorance of media or forms of transmission has been found to be quite general in daily life and business (McLuhan, 1965).

Studying level interfaces in games as well as other simulation models, it appears that their main function is transmitting certain objective or subjective information from one level to the other, while the levels remain separate. There are various modes available for the transmission and transposition across levels. In game design, the choice for a particular mode of transmission between levels is important to secure a better quality of play. Moreover, if the transposition between levels is not done correctly when analyzing simulation results, serious statistical mistakes can result (Alker Jr., 1969). Often, however, the meaning of the information is not quite the same on both sides of the interface, which is a result of the fact that the levels are different, each with their own dynamic interpretations of symbols that may even be similar. In simulations this difference between interpretation is even larger than in reality which allows games to be clearer than reality, but make them at times a bit of a caricature.

Three modes of transmission between levels of aggregation in simulations may be identified: responsibility, symbolizations and tallies. In order to explain these general modes it will be attempted to relate these to some items that have been listed as essential to the making of a gaming simulation (Armstrong e.a., 1972).
Those are roles, rules and records (the three R's of social simulation?). Roles form the element particular to participative simulations or games: the interacting agents involved in a process of decision making who are represented by real people acting in a certain manner. Rules are the detailed procedures most of which resemble reality but some of which serve only the limit, speed up or further clarify the simulation. The third item has been called the scenario in other sources, but is labelled here as records since that is the form, which scenarios from the past usually take, apart from background information for the roles and historical information on rules (see the preceding two items). The records, be they quantitative scores or statistics or more qualitative descriptors or assessments need to be prepared when a gaming model is built. Of course roles, rules and records depend on each other. Often

roles are meant to maximize a particular record and the rules spell out how far they can go in their effort to do that. Roles, rules and records will be found on almost any level of aggregation in complex models. Transfer of information will orginate from, be directed to, and make use of roles, rules or records or some combination thereof from the levels concerned.

When a role is to be used for the transmission of information, then a person from one level of aggregation is delegated with the responsibility to communicate the particular fact or opinion to the other level. This responsibility may contrast a particular role from others, it may call for a set of rules about representation, it may simultaneously set goals or constraints for one level and be merely a means (information gathering) for another level.
Responsibility for carrying some information across may arise from a request from one or two sides or it may originate from a previously made agreement or shared historic scenario. Probably the transfer through a responsible agent has a particular place and time slot in the game's procedure. It requires a player with some authority and contact on both levels who should devote some time and energy to this task. Transmission by responsibility carries with it all sorts of risks and opportunities that go along with the person doing it: will the player pay attention to those whom he or she is to speak for, will the participant trigger certain memories with those he or she is to speak to, will his or her appearance on the other level be stimulating or pacifying, will the person involved not be kidnapped by still others?

Rules cannot be used themselves to transmit information from one level to another in a model. They are an abstraction that does not go from place to place but that can attach particular meanings to certain symbols or procedures used in the game.

Symbolization is employed frequently as a way to have a meaningful impact on another level, e.g. the competition for space by individual developers in the city as a whole can be represented by bidding for sections of land on a playing board as in CLUG. Other symbolizations often used in simulation games include furniture, [illegible] arrangements of the room, ropes, caps, badges and unit-materials such as blocks, chips, stickers, marbles, play-money etc. Although these may look like simple paraphernalia added to foster the participants' involvement, they are powerful means to communicate desires and limitations. As some of these artifacts are readily assembled in one step, phase or level and easily addressed to another, these symbols can form a very tangeable link between levels of aggregation.

When records are used for the transmission of information across level in a model then this kind of interaction is not so much typified by numerical value or by the contents of the verbal assessments but rather by the deployment of an impersonal and highly concentrated tally or variable as such. Instead of using a pile of chips of a particular height or a person instructed with particular arguments, a number or written report is used that carries a certain meaning. Simulation games that contain a lot of statistics and written records are sometimes labelled form-games after the pieces of paper on which all this information is recorded. Quite often forms are transmitted and used in the simulation at another point where decisions effecting a larger or smaller aggregation will be made. The tallies may involve information with varying degrees of certainty, ranging from deterministic to probablistic records.

At this point it may be useful to describe some examples of simulation games in which information is carried from one level to another by responsibility, symbolizations and tallies

(The "R.S.T." of level interfacing?) respectively. This will yield a further insight into these modes of communication for connecting levels of aggregation.

First an instance in which responsibility is used to transmit factual but probably also emotional information.

In the simulation game BINNENSTEDELIJKE RANDZONEBUURT (Buit, 1975) three role-groups prepare plans for a run-down area close to a city center. Two roles are concerned only on the level of that particular neighbourhood: the residents and the small shopkeepers. The third group transcends this level in its role-description: it represents the interests of the city at large including the downtown area. Of course, what happens in any one neighbourhood will be affected by developments and opinions in the rest of the city, and in this game the means of a role is employed to represent that interest in a very continuous, responsive and personal manner.

Incidentally, one of the findings from simulations with this game was that city players did not like to tackle the problems of the delapidated area one after another. To them it appeared inconsistent that, after asking for a commitment towards rehabilitation and open space first, the area-specific roles next demanded public funds for the relocation of factories that produce a nuisance and for the construction of a community center and a school. While in the terms of the neighbourhood the first needs have been met, this area, compared to other areas in town, may still look old and lacking in parks and playgrounds. Also, if public approval is necessary, it is always difficult to change priorities in mid-course. This game inspires formulation of hypotheses about the effectiveness of particular approaches in urban renewal, and it provides a useful training tool because the different interests must be verbalized by the participating students. With this objective in mind, the choice to represent the other level of aggregation (the whole city) by a role appears to be an intelligent one.

Second, I would like to offer an example of gaming-simulations in which information is transmitted from one level of aggregation to another by means of symbolization. A gamelike form of survey comes to mind. Surveys of this kind have been designed to obtain more realistic predictions regarding future satisfaction with items of choice. The MILIEUSPEL as used in several Dutch appreciation-surveys for residential areas (Sociografisch bureau, agglomeratie Arnhem, 1972; ETI Overijssel e.a., 1972: ETI Overijssel, 1973) are derived from the Wilson game (Wilson, 1962) which probably inspired a similar British proposal on traffic and environment (Hoinville, 1971) as well. While these individual exercises are almost like puzzles or questionnaires I would still want to classify them as games, because they provide feedback on participant decisions and allow going back and revising earlier decisions.

In the MILIEUSPEL the steps of play are as follows. Each participant is given a form with all materials for play including stickers, the graphic expressions of the options in areas of choice, slots to allocate the appropriate number of stickers for the options on and an address to mail the filled-out form back to. Participants first choose on the basis of illustrations the kind of neighbourhood they want to live in: central urban, low density urban, suburban or semi-rural. On the basis of that choice they receive a certain number of points, symbolized as stickers.

Next, the participant is asked to indicate with these stickers which of several shops and services should be planned close to the homes. More points are required to bring something within walking distance than to have space for it reserved within driving distance. And, of course, the cost of having schools or shops etc. brought close to home is greater in less populated areas, while it is almost automatic in neighbourhoods with a higher density. The idea is that one cannot ask for a perfect solution on one item without finding that one will have fewer resources left to ask for a desirable solution on another item. The trade-offs made by the respondents are what the game designers and users wanted to know. Once the respondents had filled out the form and realized how far away they would live from various items, they were allowed to revise their choice as to the neighbourhood or density once and to allocate their new number of points.

The decision to live in a dense or a less densely populated area is one of another level of generality than the choice to have a grocery or a mailbox nearby. As the first decision governs the number of points one can spend on the latter, it is these points that must be regarded as the linking mechanism in operational terms between the levels of generality. Incidentally, a North American PhD thesis (Johnson, 1977) utilized sketches to illustrate all the other items of choices as well as in the British proposal. Parallel with the graphic game-like part similar questions were asked in the American case using a normal questionnaire with check-off boxes and without trade-offs. Both types of questions were asked of people who were about to choose a new house, and a couple of months later the respondents were checked to see what kind of home they had actually got. The answers to the game-like part were found to be somewhat more predictive of the actual choice than the regular parts of the questionnaire. Apparently showing the pictures and requiring different options to be traded off using a limited number of stickers induced more realism on the part of the participants from that area.

Thirdly, it is easy to find examples of games involving tallies as a way to relate information from one level of aggregation to another level. Practically all simulation games as well as many entertainment games include a point system to summarize the results in sections of the game, and if there is any jump in levels involved it is usually that condensed tally that is carried across to the other level.

A game that includes tallies that are additive as well as ones that operate like an index can be found in SESRO-4 (SESRO, 1970).

This is a Dutch land use game inspired by the American series of LOC games (Kibbel, 1972). A small number of parties or teams is engaged in the commercial development of a city. The urban growth and reconstruction is differentiated into the sectors housing, employment, shopping and recreation. Some of these kinds of land use go well next to each other and will both increase in value if adjacently located (e.g. residential and recreation). Some of these land uses will hinder each other and some points will be substracted from the value of the ones bothered most (e.g. from residential, if residential and industrial are located next to each other). The concerns of complementarity of adjacent land uses is of another level than that of the developer for one of these land uses.

In reality this difference in levels exists too, and one of the corrective mechanisms at work to prevent excessive development of particular kinds of land-use is the price, which drops if there is plenty of that kind. At the same time an abundance in one sector will indicate a relative shortage of one or more other sectors, which can be corrected by carefully planned particular actions or by a general corrective mechanism such as a higher price of units of these other kinds of uses. In this game both the planning and price mechanisms are included, the one forming a check on the other. Every third round there is a planning meeting and a period for each term to assess the value of its possessions.

Based on the proportions of units realized up to that point the game moderator computes a multiplication factor for the values of each kind of land use. After this index is passed back to the playing teams they can compute the final values of their holdings through multiplication. Incidentally, the next round will begin with a planning phase, in which the parties can agree in which case the prices will normalize and will actually not have been necessary as a corrective impulse.

Yet the developers holding the scarce and more valuable kinds of land use may, alternatively, not have built any more of that kind, so as to increase the value of their holdings even more. In time, however, the high value of the scarce land uses will motivate other developers to enter into that branch. Thus if either the cost of entry (time for orientation) is low or one is willing to go by a plan, a balanced growth for the urban area will be achieved. The tally that goes back and forth between the levels of aggregation in this instance is a certain, definite and real number. Its actual implications, however, are not so predictable since they depend on the intentions of the players with and without experience in the various branches or activities possible.

This concludes the examples of simulation games in which information is communicated between levels of aggregation by means of responsibility, symbolizations or tallies respectively. Two general points remain to be made quickly here. First that most games involving different levels of aggregation will utilize more than one of these modes of interaction, and second that the interface between levels is only one part, probably a minor part, of the game's structure.

3 Choice of mode

Why is one mode of interaction between levels of aggregation used rather than another? Some insight as to this choice for game designers and other model builders may be obtained by looking at pairs of games about similar subjects. If in one game the transmission across a level-interface is done through a particular mode, and another game can be found where a similar content is to be communicated across a similar interface, but using another mode, then some inference may be made about why or under what conditions one mode is to be preferred to another. Hence this section will describe pairs of games in order to contrast their modes of interface.

The two examples illustrating the choice between the modes of responsibility and symbolizations concern games that were used intensively in the Netherlands some time ago.
The first, OOST GRONINGEN (Raadgevend Bureau Berenschot, 1971), is a game about the allocation of recreational objects (camp grounds, pools, restaurants, woods, lakes etc.) in a large and relatively underprivileged agricultural area. It was developed by a consultant firm and run in about ten villages and towns in the area to get to know citizens' preferences as to the location of the planned facilities (de Vries e.a., 1971).
The second is called O.O. EVA (Gerritsma e.a., 1973) and deals with the choice between several methods of examination for medical students (e.g. oral, essay, multiple choice, examination using cadavers, or simulated patients, etc.). It was developed by the department of medicine at a University where students had (finally) obtained the right to cast some of the votes on such issues of curriculum design (Gerritsma e.a. 1975). Both these games include a slight change in the level of authority of the process, which produces some difference in the level of aggregation between the beginning and the end of play. The way this change is expressed and the dynamics this produces is very different between these games.
In the OOST GRONINGEN simulation game, the citizen participants are invited in the first series of runs from one town or village at a time. They are asked to group themselves by interest, e.g. farmers, retail, industry, tourism, etc. and to prepare a plan for the allocation of recreational facilities and pin it up on the wall. Then they are asked to assess the plans of these various interest groups and to select or ammend the one they like best. This was done in about eight places. In the second series of runs they no longer represent solely their interest group but they start to take responsibi-

lity for their village as a whole. Then the maps produced in the first series of runs are discussed, altered and chosen from, subject to the same constraints of facility cost due to soil types, population distribution and demand from outside the area.

In these runs a small number of plans were decided on that were recommended to the regional recreation board as suggestions from the public.

In O.O. EVA (which uses the same basic structures as SESRO-2 (SESRO, 1970) with weighed random factors), the main change takes place in the use of symbols or icons during the phases of play. First participating students select criteria for evaluation methods and then consider the particular courses in their curriculum.

The participants take in this the of view of the various subgroups that are represented in curriculum committees (e.g. beginners, advanced students and graduate students, junior and senior faculty and administration). These preferences are filled in on a matrix where the suitability of one evaluation method for one course is computed directly from what the participants have entered. But in the end, the participants are confronted with the final decision in which a large weight is attributed to cost and other practical considerations as well as to a random factor. Things then are determined by a kind of slide rule in which the participants preferences enter as only one of the three elements. Again, this involves a slightly different perspective, namely a more final and executive responsibility.

With OOST GRONINGEN the change in level of aggregation was introduced in the course of the first runs. At the end of that first series, the participants had to select one plan and select someone from each of their interest groups to form a team to enter in the final series with all the other towns and villages. It was through a change in responsibility i.e. they now were representatives of their entire village, that they were made interested in negotiating for more than their private interest. The people themselves were transmitted to the new level i.e. their role had changed slightly as they went to the central town to participate in the latter series of runs.

With O.O.EVA the change in level of aggregation was introduced by the game operator not by asking for participation in a subsequent run but by using symbols differently during a final wrap-up of that very same run. In that phase, the operator uses outside data, the importance of which was not previously made explicit or experienced (a procedure more acceptable in a game than in reality). This part of the simulation is no more than a show of higher level of authority which is not played by people but rather is simulated by means of one binomial (cheap or expensive) and one random (cast a die) factor. From the more overall level of responsibility to the old aggregation of representatives the transmission is through symbols, in this case through the special slide rule. The participants of OOST GRONINGEN mostly reacted positively: eager to go to the final game and willing to construct a compromized collective plan.However, some of the participants of O.O. EVA reacted negatively, saying they felt out of control as the cost considerations and the random factors were brought into focus on the sliding game board. Yet it is premature to say that carrying information across with roles is better than with symbols. This depends on the precise purpose of the game. As to specific instance at hand, OOST GRONINGEN did not prepare the citizen participants to deal with the recreational board deciding on a plan after the participant's recommendation was made. In fact, the board adopted its own plan incorporating elements from but not copying wholesale any of four alternatives the citizens had presented.

On the other hand, the students choosing exam-methods knew, after playing O.O. EVA that it was important to talk with the professors especially about the cost and time factors involved in evaluation methods.

It appears then, that the following trade-off may be hypohesized between responsibility and symbolization: the former fosters more identification, probably yielding both a willingness to play longer and more creatively, while symbolizations enhance some distance and analysis, furthering an assessment of what has been done that may be more cunning and realistic.

Next a pair of simulation games will be discussed that provide an illustration of the choice between symbolization as a more iconic way of transmitting information and tallies as a more numeric mode of interfacing levels of aggregation. The examples are METRO-APEX (Duke, 1971) a successor of the METRO game mentioned earlier, and SNUS (Carey, 1977?) which looks somewhat like the HEXAGON game. METRO-APEX is an urban development model, involving real estate developers (housing and commercial), public officials (social facilities, open space and infrastructure), politicians (of urban and urbanizing wards) and the optional roles of a school board and an air pollution board. It is used for the training of air pollution control-officers e.g. in Southern California.

SNUS is a game developed as part of the aid to developing nations and attempts to present an overview of the nutrition system. Participants are involved as local famers and consumers, regional tradesmen or national policy makers, and it has been used for students from developing nations on courses in industrialized countries.

Air pollution cannot be contained unless measures are taken regarding the entire urban region involving areas of policy as diverse as transportation planning, land use control, industrial processes and nuisance control. Similarly the nutrition of a nation cannot be improved simply by some new crops unless things are done at the same time about transportation, storage and the training of people on how they produce and consume the new food. Yet developing overall strategies on pollution or nutrition is futile if on a very local and practical level these policies will not be carried out. In both instances a gaming exercise was desired presenting both the narrow and broad view.

With METRO-APEX there are at least two ways in which the interests of the individual players can be classified. First on a lower level of aggregation the different roles are those of the central city, suburbs and urbanizing townships. Second the higher or city-wide level is differentiated by subject matter e.g. housing, employment opportunities, services, infrastructure, recreation, real estate, traffic, school, pollution, etc. (This appears to beg the question who addresses the overall city level without subdividing it into some lower level of aggregation).

Of every round, the area-specific results as well as the ones by subject matter are compiled and summarized by a computer before the next round. This includes the consequences of decisions made on one level of some dimension of dis-aggregation on factors concerning other levels or types of specialization. These information transfers generally take the form of tallies such as popularity scores, clear decision options, simulated money, size of land holdings, numbers of residents or employment opportunities. Apart from negotiations during the rounds, the confirmation and derived computation of these records is prepared by the computer that prints out a newspaper as well as some statistics, accounts and decision forms for every role every round.

In the dual role of a function-oriented professional or politician and an area-specific worker or promotor, most participants will feel crosspressured. With respect to the subjective interaction between these levels of scale the double allegiance may feel like a matter of competition, while on the objective level the transmission of constraints and options between the levels may appear more like a matter of coordination.

While in the preceding example the mode of contrast between the levels of aggregation included tallies and other statements from a computer (as well as role interaction), in SNUS the interface encompasses some of the symbolic paraphernalia used in that game (again next to role interaction). Boards with blocks of various colors and shapes are used to represent four different kinds of food, as well as public works, education, health, energy, raw materials, fertilizer and tools. Products can be physically handed over from local farmers and miners to the regional tradesmen or to the national export ministry. Deficiencies can be physically supplemented on the population and consumption boards if e.g. regional level can sell some of the excess produce of one land unit to the unit where the deficiency occurred. Transportation and storage losses can be actually taken away at various points in the process. A significant part of the interaction between the local, regional and national levels, therefore, is done by the manipulation of symbolic objects rather than by computing scores.

The difference between modes of interface based on computer tallies or on symbolic artefacts can be explored by looking at METRO-APEX and SNUS in their use. The partly computerized game appears to have some advantages. The advantages over implementing all decisions by hand seem to be 1 speed and ease for the game operator (as long as the computer works appropriately) 2 inclusion of less obvious but in fact predictable cross-impacts, and 3 objectivity and confidence for the participants. The disadvantages may be threefold as well: Firstly, when the result of previous decisions is brought about by some symbolization, it immediately involves other people. The game coordinator or an assistant will come over to manipulate the paraphernalia, and fellow participants will recognize the gains or losses immediately. Meeting these other people at that time can help in recognizing the total impact of such consequences rather than to focus all attention on the one aspect that one numeric tally reflects. With computer information or with numbers generally, an additional social step is required to make these impersonal tallies come across like real feedback. This can affect the style of play as ways to find out the social or operational meaning of the "dumb" figures are sought more eagerly. In the case of computer use, moreover, the similarity in form between all role-specific output-tables may become so great that a real identity seems available only to those who achieve something special. I'd like to hypothesize that simulations involving tallies will tend to be more competitive than those involving more iconic and manual (personal) symbolizations.

Secondly, a disadvantage of partly computerized simulation games is that unexpected or unintended effects will be entered by the computer only, which has something of a blackbox effect. It may be easier for the participants not to have to see all relations at work, and indeed it will be instructive for them to participate in the simulation that is going on correctly albeit through unknown corrections, but more learning may take place in manual games where all the effects of the decision are called out and effectuated for all to see. Then, at least the participants will know there are specific and possibly predictable cross-impacts to be taken in consideration when preparing the next round's choices.

Thirdly, only when all stocks and flows are made clear to see, is it possible for the players (possibly experts in the area being simulated) to make remarks about things they see as being represented inadequately, thereby adding to our explicit understanding of the process at hand. Indeed simulation gaming is one of the few methods of scientific inquiry that allows for this direct type of commentary during its application; one of the few research tools with a built-in safeguard against mistakes as long as the game's operations are not carried out in a concealed manner.

Perhaps it is for reasons like these that the proposed computerization of SNUS would not affect the steps of play effectuating the impacts of decisions. Rather the computer routines would be used by individual participants or small teams before they make their decisions. Of course these computer programs, meant to offer some prediction of the impacts and cross-impacts to be expected when a certain option is exercised cannot include the effects of simultaneous choices made by other participants with certainty at that point. But still, the use of computers in preparing game decisions will yield some preliminary insight and will certainly be different from computer use in confirming or implementing player decisions. It appears, then, that the following trade-off may be hypothesized between an interface using symbolization versus one using tallies: symbolization provides stronger involvement, more learning and probably more creativity, while tallies are less laborious, less ambiguous, creating more player confidence and possibly more competition.

Finally, a discussion of the mode of tallies in relation to responsibility is in order. The difference between these modes of interfacing levels of aggregation can be illustrated by looking at two Dutch games in research on the planning process for urban growth or redevelopment.
The first one is called SIMPELDAM and was run initially in eight towns to explore the present communication patterns in planning new residential neighbourhoods and then run another six times with a revised hypothetical structure for citizen participation (Burie, 1974). This new structure appears in the gaming simulations to improve the chances for the future inhabitants of the area to have some influence on the design and position of the houses and a pilot procedure like it is now being used in planning practice. The second one is called ESP (which refers to the Dutch for Evaluation of the Urban-renewal Process and was run with four experimental groups to compare two forms of project organization that have been used in medium sized Dutch towns in starting urban renovation-projects (Smit e.a., 1976).

Both gaming models include the step between what is planned for the neighbourhood as a whole and what the contributions and consequences are for particular groups, enterprises or agencies. This involves a difference in level of aggregation both in the plan's contents and in the planning process. In these research games the items observed had to do with people's role perceptions, the feeling of understanding, belonging, having options, being in control, being heard, having confidence, keeping secrets, etc. The major difference between these two gaming simulations as research tools is that in SIMPELDAM the participants were asked to provide much information themselves about their perception during play, in the breaks between rounds, with observation being more piecemeal and specific. In contrast, ESP had no rounds and questions were asked only at the end of play, while some four observers were taking notes more continuously.

Both observation methods have their drawbacks. The repetitive self-assessment of participants in SIMPELDAM produces a heightened weariness of certain aspects of their position which is not realistic. The use of indirect data from observers rather than from the players themselves, in ESP may have resulted in material that was easy to observe rather than of real importance.

The exchange of information between the larger level of the whole (re)development plan and the smaller level of each of the separate interests was achieved in both of these through role play i.o. responsibility. What can be usefully compared here is the impact of the different modes of data collection on player motivation. With SIMPELDAM, most of the information collected on the way people felt about the total process was phrazed in the questionnaire in the form of tallies, like scores on a five point scale. Its impact in terms of making the participants more aware of their competitive or cooperative stance was possibly a little removed (the questions were put during time-outs, they were very specific, and to be ans-

wered individually in silence).
With ESP the continuous observation did not provide any feedback nor regular periods of reflection for the participants. They were aware, however, of the total process being observed. They felt responsible for their progress and made this concern part of the simulation as particularly the citizen participants eventually brought it up in every run. The municipality, especially the politicians, felt obliged to respond to that concern of speed and clarity every time. The observations show that this concern typically starts in a factual manner (like: we have not seen any progress, they still have not said whether any houses will be torn down) and will then be discussed in a more emotional manner (like: the citizens no longer have confidence in this process, as representatives of the neighbourhood we quit participating in some of the project groups). While the interface may have looked like frequent time-outs with SIMPELDAM it apparently looked more like gradual build-up of the otherwise not-so-clearly simulated respective constituencies with ESP. It is contended here that the way the data were collected, through intermittant tallies or through continuous observation, did have some bearing on the manner in which the players acted with respect to the procedure or organization structure being tested in these games. Perhaps the choice for a tally-oriented means of observation regarding the interface, as in SIMPELDAM or a responsibility-oriented one as in ESP can be related to the objectives of the researchers who developed and used those gaming models. In working with SIMPELDAM the objective was to think out and subsequently to test a planning procedure that would improve the chances for citizen participation. That means a new conception for the total process had to be developed and the game runs were to serve as a basis for a debriefing discussion with participants who were all sensitized to the issue of citizen participation from their own role perspective in the simulation. In working with ESP the objective was to compare

two existing organizational structures for plan preparation of renewal project. That means that the problems caused by the growing awareness of the larger process were to be introduced, and the capacity of typical factors under each of the organizational structures to solve these problems was to be observed. It makes sense with the former to look individually-repeatedly and in depth at the self-perception and process-perception and other factors stimulating citizen involvement, while with the latter it seems appropriate to deal with feelings and decisions at the participants' pace and to observe the way they were handled collectively.
It appears then, that the following trade-offs may be hypothesized between the use of tallies or responsibility in communication across a level difference: responsibility is warmer, and more holistic while tallies are cooler and more specific.

Thus, three hypotheses have been developed regarding preferences as the made of linkages between levels of aggregation. In these hypotheses the preferences in that area of choice to game designers are related to characteristics of the simulation that are likely to result. This underlines the importance of knowing before game construction, or discussing in an early phase of game construction, such desired characteristics as atmosphere, insight and involvement to be furthered by planning the game.

4 Conclusions

Simulation games provide a participatory means for exploring relations in complex systems. Because of their intrinsic involvement they are a powerful tool for training or policy testing, particular in cases where a small group of people have to be trained (e.g. a newly formed committee coming to grips with its tasks and procedures), selected (e.g. Assessment Center Technology) or consulted (e.g. on interdisciplinary subjects). Particularly now that issues of coordinating different levels of scale, of reach, of authority, and of specificity in real world processes are of increasing importance in society (Friend e.a., 1974), this topic of game construction has become of key importance.

Choosing a mode of interface is not a matter of knowing the correct modes for once and always, but rather a matter of trade-offs.

Depending on the purposes and subject matter of the game, one mode of transferring information between levels of aggregation will be better in one case and another mode in another case. Three of these trade-offs were formulated as hypotheses in the preceding section of this paper. It is important then that the purposes as well as the subject matter of the game are known before design starts. Is the simulation meant to foster close identification or remote analysis? Are involvement and learning desirable or clarity and confidence? Should warmth and holism be valued or is it better to be cool and specific?

The hypotheses from the previous section, relating objectives like these to a preferred type of interface, are only very tentative: 1 They are the result of only a few pair-wise comparisons between simulation games, 2 They rely heavily on differences in game structure on sometimes rather minor points, 3 They are the result of subjective interpretation by one person at this time. However, they are presented here as example of a particular way of thinking: a game can be designed to meet objectives, no only by making use of suitable components and structures on any level in it but also by choosing suitable modes of interface between the levels.

Too often, game designers think in terms of such practicalities as specific gaming techniques or dynamics which they know will work. Granted, it takes a lot of time to produce a well-balanced game even when using only such tested and tried components that come to mind first. But the product will not be successful

if it does not meet its objectives. And there are so many games by now, including such a variety of representational techniques and dynamics, that a game designer need not feel very much constrained in his techniques. Often there are choices to be made, it is contended here, when constructing game sections (e.g. levels of aggregation) or their linkages.
The objectives and constraints that can guide the choice to be made in game design should be specified primarily by the future user or the person or group that gives the assignment to produce the game. In most situations, however, they do not know immediately what they want in great detail. The game designer has to help the client to become aware what objectives are possible. Thus, the process of specifying the game's objectives becomes a continuous one occurring in an ongoing debate between those giving the brief and those constructing the game.
A list of questions has been proposed to help game designers and their clients to formulate the objectives for a simulation game (Duke, 1974). It would be helpful to split that list into phases to match an incremental manner of arriving at game specifications. Just taking section A of the existing list provides a good start but does not touch on the relation between the game assigner and the game designer: Things like responsibility for information, facilities for test runs, names of experts in the area, payments, copyrights and procedures in case of disagreement during the further process may well be included in a first "brief".
Subsequent refinements of the game's specifications can be obtained later, using perhaps the other sections of aforesaid list and regular discussions with the client to sensitize him or her to the opportunities and difficulties with gaming. Possibly the client or his representative can visit a run of another game to see some component or dynamic at work. Possibly he or she is sufficiently open minded to come and see one of the preliminary and probably awkward test runs of the game at hand.

While leading to a game that is better suited for its particular task, the continued debate between a game designer and the client can be frustrating too. First of all the client is anxious about the subject and the method of gaming, otherwise he or she would not have called for a gaming consultant to come and help. Secondly, some clients have difficulty committing themselves and will want to keep the game's objectives general and impossibly broad for a long time. This leads to vague discussions and the possibility of losing interest. And finally some game designers do not feel sure they can meet the increasingly specific set of objectives and may hedge the debate till after some proof runs. It is contended here that it is better at least to enter into a discussion of objectives rather than assuming these objectives will fit a particular technique or certain balance of dynamics that one person thought out or remembered. The latter approach, however common it may be, appears to shun explicit consideration of objectives. This happens all too often with media, of which games are one. A more open investigation was motivated, be it somewhat rhetorically, in a book on media and their social impact (McLuhan, 1965).

> "So what is to be done? Do we dare confront such facts at conscious level, or is it best to becloud and repress such matters until some violence releases us from the entire burden?...It may be merely temperament in my own case, but I find some easing of the burden in just understanding and clarifying the issues. On the other hand, since consciousness and awareness seem to be a human privilege, may it not be desirable to extend this condition to our hidden conflicts, both private and social?
>
> The present book, in seeking to understand many media, the conflicts from which they spring, and the even greater conflicts to which they give rise, holds out the promise of reducing these conflicts by an increase of human autonomy". (op. cit.p. 51).

With a similar aim in mind, albeit for the limited context of gaming, a procedure will now be presented for more systematic research on game components and on the trade-offs that can be made explicit in game design. An important element in this procedure is the notion that good simulation games are well-integrated entities in which the different components rely on eachother. In general, the modes of interface between levels of aggregation are related to basic components of game design namely roles, rules and records. That means that the choice of a mode of interface is constrained by a choice for particular roles, rules and records on any one level. For example tallies cannot be used for linking levels if on none of these levels any quantitative records are generated. Conversely, if the role-play between levels produces a lot of excitement, the attention for dull or written or individualized information about processes on a particular level may be reduced. It is important, then, when putting a game together, to realize what the choice of game components for any level or part of it implies for linkage possibilities and vice versa. Both the representation of any one level and the mode of interface can contribute to achieving the simulation's objectives. In as much as the elements on one level and the particular ways to link these have been included in existing games an assessment of their mutual effects is a matter of information retrieval. In as much as these components or their juxtaposition is new, a good operational understanding of their nature can be obtained by experimenting with a pair of games that differ only on the point of that novelty. The proposed procedure for further research then, is twofold. First, it involves the making of a register which has been proposed before (Smit, 1975). Second, opportunities for comparative experiments with games including new elements or linkages should be spotted and utilized. As to the register it should include elements and linkages from well-developed simulation games and should contain particular items on roles, rules, records and any other elements that occur in the represenation of one level as well as particular forms of the interface between levels of aggregation. The register should be indexed in several ways, providing different dimensions of retrieval for the game designer who wants to be sure to check all relevant techniques.

Firstly, there should be an index by subject matter. Is land being represented or time or energy or cohesion or what not? Secondly, an index should be provided by type or technique. Does it involve a role for a participant or a rule for the operator to enforce or a record for all to see. It is deterministic, stochastic or behavioral? Questions or marks of differentiation along this dimension still have to be thought out.

Thirdly, an index will be needed of successful collaborations or mixtures of these components. This is the most relevant dimension in the context of this paper. What modes of communication between levels of agreement go well together with a particular technique or dynamic on a certain level of the game? And what does that mean in terms of the paraphernalia and kinds of activity that can be built in on the next level? Finally, an index will be essential as to the objectives of the game served by the various game-components. Assessment by users rather than by designers may be preferred on this dimension.

A register, like this, although a tedious matter to set up and keep up, would provide game designers with a valuable tool, linking them all into a common pool of experience. If the intended repertory of gaming techniques is devised and used intelligently, it would enhance flexibility when designing new games as well as when adapting existing ones to new tasks or to other cultures. Analysing a fair number of existing simulation games for the purpose of entering their components in the proposed register, will already reveal certain sets of components that go together frequently. If so, it may be possible to find statistical indications, as it were, for such binding principles as emphasis on responsibility, on symbols or on tallies in the integration of game levels. As to the experiments with pairs of simulation games, opportunities must be found to run such games with similar objectives, for groups of similar participants and in general under conditions that change little. Such circumstances are more likely to be found in a teaching or training context, with its large and relatively homogeneous groups, rather than in policy-preparatory uses of gaming. While these are some differences in principle between educational and research or policy-preparatory gaming, the latter only stands to benefit from information about particular game components obtained from tests done in educational games.

While it is impractical to wait for the results of the double-headed, more systematic research, it would allow clients after they give an assignment for game construction to be informed somewhat earlier and perhaps with more certainty about the feasibility of particular combinations of objectives for the gaming simulations they desire.

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3.9 Drs. V. van Veen, Institute for Andragology, University of Amsterdam, The Netherlands.

More enjoyable games: how to increase the subjective value of games.

Like most people, I am looking for ways to make life more valuable, more enjoyable. In this paper, I will try and apply my theory on what makes life valuable to games. First the theory will be presented; then the connection to games will be made; that will lead up to a questionnaire on how to make games more valuable, more enjoyable. Your feedback on the questionnaire should give me some of your ideas and knowledge and thereby help improve the questionnaire, the value of games and the theoretical framework. So do please send me reactions and comments.

The value of a life or an activity can be measured in many ways. Some people consider breadwinning more valuable than child-rearing, cycling better than driving, laughing better than learning or vice versa. As long as people disagree about what is better, improvement is difficult; it will not be possible to please everybody. One solution is to accept the subjective verdict: if a person considers an activity more valuable it is more valuable to her (or him). If there is no feasible way of establishing an 'objective' verdict, it may be the only solution. At any rate, the subjective verdict is central in this theory.

If a person feels that playing a certain game is or has been valuable, that makes it valuable to her or him - apart from 'objective' measurement of the value. In that sense, if we can make a game more enjoyable, we have made it a better game. (However, for a Puritan who needs to suffer for his self-respect, the reverse may be true!).

Generally speaking, people consider things worth doing because they enjoy doing them or because they like or want the result of it, or both. If people value doing things for their own sake, we can say that those activities have intrinsic value for them. Examples are: going to a party or celebration and leisure - activities in general. If an activity is valued for its results, outcome or product, we can say it has product value. Doing chores or cleaning the house are examples of this.

There are activities that have both high intrinsic value and high product value. Think of doing research or attending conferences: it is enjoyable and it has product value. At least that is what everybody hopes, that is why we are paid for it.

Intrinsic value and product value of activities may influence each other. A person who enjoys cooking - or working - is often a good ('productive') cook - or worker. That is why so many millions have been made available for research on work-motivation. On the other hand, a demand for more product value may so dominate people that the intrinsic value diminishes or even becomes negative. This happens in bad jobs and in bad schools.

We can assume that the total experienced value of an activity is a combination of its intrinsic value and its product value.

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Improvement can be achieved by increasing either.

The product value of activities has received a lot of official attention. Increased productivity of our activities is responsible for our wealth. 'More of the same' does not necessarily give the biggest increase in the total value of our activities. Think of 2 people doing the work of 3 if there is no valuable employment for the third.
Also: your fifth pair of shoes does not really make you a happier person. So it may be that increasing the intrinsic value of activities becomes more rewarding.

Let us examine intrinsic value more closely. What makes for enjoyment, for valuable experiences? I would say it comes from three different but interrelated sources:

1. The value attributed to physical and sensual perceptions (comfort, beauty, excitement, etc.). Taste and threshold of awareness vary over people and circumstances; rhythm, harmony and contrast seem to be important.

2. The value of the emotions engendered by the activity (it may cause a feeling of competence, freedom, solidarity etcetera). Apart from differences in taste (some people do not like solidarity all that much) there are also differences of interpretation (a challenge for A would be a threat to B; what causes 'competence'-feeling in the one may cause feeling 'incompetent' in the other).

3. The meaning attributed to it, the relationship to a value or ideal. (Think of the intrinsic value of rituals - a catholic mass, the opening of parliament - but also of the extra pleasure it gives to work for a good cause or for someone you love.

In general, intrinsic value is determined by the experience of people during the activity. 'Meaning' however may also be attributed afterwards. The activity then acquires new intrinsic value in retrospect. In gaming, this often happens in the debriefing. 'Meaning' seems to be a strong point for the intrinsic value of games. Within a welldesigned and presented game, every decision, every activity has meaning. In a world where many people feel their activities are meaningless, this may well provide an important corrective emotional experience. Also, where ideals and value tend to be more individualised in our culture, games may provide people temporarily with solidarity and a focus for collective action which they sorely lack in real life.

Since people have different tastes, what is a valuable activity for some may have negative value for others (e.g. boxing, smoking).
Also, if people play different roles in an activity, they will value it differently (think of winners and losers). In gaming, I assume that ethics demand that no player has a negative total value and that the lowest total value should be as high as possible.

Now it is obvious that whether or not you enjoy yourself is a question, not only of your environment and its possibilities, but also of your reaction to that environment. Some people are capable of enjoying themselves under the most unlikely circumstances. Others seem to always find a good reason for feeling miserable.

Therefore, if we are looking for ways to make the games more enjoyable, we can look at the environment of the players.

We can try to create processes and circumstances in which it is easy for most of the games' target people to enjoy themselves. This is the object of the first part the questionnaire, giving attention to characteristics of the game-environment, director, players, Gestalt of the game, game-material, roles, course of events and players' play respectively. We must however remember that a game is a 'Gestalt'.

The complementary approach is: looking at the possible reactions of players. What strategies can we advise players to use - to make playing the game (or life) more enjoyable?

That is the object of the final section of the questionnaire.

Questionnaire for more enjoyable games.

I. The game-run: providing better opportunities.

You have 100 resource-units available for ensuring a particularly enjoyable run of an unspecified game. I assume that you will spend the resources moreless systematically, by:

1. Deciding which aspects of the game-run are important for enjoyability. Please rate each aspect from 1 (prime importance) to 5 (irrelevant).

2. Estimating which aspects can be expected to yield a relatively high increase in enjoyment for a relatively low investment of resources (a high joy-ratio). Again, rate each aspect as A (very high joy-ratio), B (high joy-ratio), C (moderately high), D (investing resources yields very little extra enjoyment) or E (investing resources does not lead to extra enjoyment).
   If you feel that it is not predictable how investing in a particular aspect is going to affect enjoyability, please rate F.

3. Having rated all aspects in columns 1 and 2, distribute your resources. Do not spend more than necessary on one aspect. Follow your intuitive inclination - but only after having filled in columns 1 and 2, which has made you consider all the items. REMEMBER THAT THE PURPOSE IS ENJOYABILITY, SUBJECTIVE VALUE, OF THE GAME;
   Investing towards more 'productivity' of a game is therefore only in order if you expect people to consider productive games more enjoyable.

Please do invest all of your 100 units.

	I IMPORTANCE (1=prime imp. to 5= irrelevant)	II JOY-RATIO (A=very high to E= none and F=?)	III UNITS INVESTED
a. Location.			
1. Comfort and aesthetics of surroundings (securing a conveniently located room with good climatizer, food, drink and toiletfacilities; comfortable chairs; harmonious colour schemes, arrangement etc.).			
2. Manageability of surroundings (e.g. making sure that participants feel at home to rearrange furniture, use it differently, create space for additional movement etc.).			
3. Meaning of location (securing a place explicitly different from the 'normal' location or not?;			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
associated with alienating power?; related to purpose of game?).			
b. Director.			
4. A director who motivates people through her (his) enthusiasm.			
5. A director who is competent and makes no silly mistakes or oversights.			
6. A director who emphasises that playing the game gives each player an experience that is meaningful in terms of her or his values or ideals. (Be it search for knowledge, self-actualisation or humanity).			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E = none and F= ?)	III UNITS INVESTED
7. A director who inspires mutual trust and a sense of interpersonal caring and safety in the group.			
c. Players.			
8. Configuration of participants (e.g. taking care to find participants with different qualities that make a pleasant combination; technical and social skills, emotionality, originality; give attention to real-life relations between participants that may cause emotional confusion or threatening dependance).			
9. Explicit motivation of participants (e.g. see to it that everybody knows and explicates why they come to play, what it means to them and to the			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
others).			
10. Individual characteristics of participants (e.g. refusing unpleasant or unsuitable players, selecting people who are optimist, responsible, extravert, intuitive, fastthinkers, creative or v.v. or whatever you prefer).			
d. Gestalt of the game.			
11. Meaning of the game (e.g. clarifying why the game was designed, why this particular run is played, how these aims are related to the ideals and symbolic values of players).			
12. Flow of the game (e.g. improving movement, rhythm, variety, harmony,			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
balance and alternation between stress and relaxation, excitement/arousel and quiet as characteristics built into the game).			
13. Manipulability of the game (e.g. make sure that the game provides each player with visible opportunities to influence the course of events).			
14. Improve the use of surprise elements or chance, to decrease control and predictability, to increase adventure and innovation.			
15. Content of the game (relationship to player's reality in terms of plausibility, detail, meaning etc.).			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
e. Roles.			
16. Structure of interaction (improve the scope for competition or co-operation, for flexibility in level of interdependance in case of emerging differences etc.).			
17. Distribution of opportunities among roles (equal, different but equivalent, determined by chance, skills or others?).			
18. Ensure that each role provides scope for its player to interpret it and to fill it with her (his) own choice of attitudes/values/meanings/level of involvement; that no role is			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
completely dependent on or dominated by others.			
19. Make sure that no role isolates its player, that establishing contacts and solidarity is available in all roles.			
20. Make sure that each role provides a challenge for all (relevant) levels of competence, but precludes its player from being a total failure.			
f. Game-material.			
21. Functionality and aesthetics of game-material (well-designed, available, attractive, unambiguous).			
g. Course of events.			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
22. Role distribution (e.g. players choose roles or central, exposed roles are ascribed to players with a high 'joy-potential'- social skills, enthusiasm etc.).			
23. Time management (e.g. punctuality, uninterrupted flow of events, no passive waiting).			
24. Atmosphere that is conducive to humour and hilarity.			
25. Level of involvement (intensity, tolerance of deviants).			
h. Player's play.			
26. Expressing individuality (e.g. emphasize the unexpected, uniqueness			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
or un-selfevidence in players' behaviour).			
27. Perceived usefulness (clarify and emphasize the product-value that playing the game gives the players - be it course-requirements or a new understanding).			
28. Provide feedback to each player on the impact or effect of her (his) decisions on other people or on the course of events.			
29. Build in occasions for private evaluation or reappraisal of role-connected interpretations and behaviour.			
30. Ensure that the player gets feedback on her (his) performance and			

	I IMPORTANCE (1= prime imp. to 5= irrelevant)	II JOY-RATIO (A= very high to E= none and F= ?)	III UNITS INVESTED
opportunities to perceive improvement.			
If there are other aspects you would like to invest in for making games more enjoyable, please mention them here. That earns you 25 bonus-units. Please distribute these over your new aspects (after filling column 1 and 2).			
31.			
32.			
33.			

II Players' reaction.

At the ISAGA-conference, I asked participants what strategies they use for making a given, unavoidable situation more enjoyable.

Some of their strategies are:

	A frequency	B value units	C reliability
1. Look for people to communicate with			
2. Emphasize the positive aspects of the situation, find out what you like about it			
3. Get intensely involved, be enthousiastic.			
4. Explore, find new interpretations for the situation.			
5. Give impulses, take initiatives.			
6. Relax, compose a poem, sing.			

A. Please indicate whether you use these strategies in colomn A., by filling in 3 (often), 2 (regularly), 1 (rarely) or 0 (never). Write A ± if you think you will use it more often in future.

B. You have 100 units at your disposal for expressing your appreciation for these strategies. Please distribute these units according to the value these strategies have for you.

C. How reliable are these strategies? Do they always work or are they liable to backfire, to decrease the value of experiences if applied indiscriminately (for instance, if the people you try to communicate with in strategy 1 react unfriendly). Please indicate 1 (very unreliable) to 5 (fool-proof).

Please describe here the additional strategies you use for making your life, your experiences more enjoyable, more valuable. (Don't worry if there is some overlap).
And rate them in columns A, B and C on a similar scale to your rating of strategies 1 to 6.

	A	B	C
7.			
8.			
9.			

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**3.10 Mr. D. Cross, Lecturer in Language skills, Exeter University School of Education,
St. Luke's, Exeter, U.K.**

Who is on the teacher's side?

For several years now, I have made use of games and simulations in teacher education (CROSS, 1978 : 1979). In this paper, I describe a simulation exercise in which student teacher groups were asked to imagine that they were the staff of a small Middle School (8 years to 12 years) conducting an important staff meeting lasting for exactly one hour.

Preparation

I began by reminding each group that we had two hours at our disposal, and that we would use exactly one hour part-way through our session for a simulation exercise. There would be plenty of time to prepare for it, it would not begin abruptly, and there would be plenty of time to talk about it afterwards. They would be asked to imagine they were the staff of a small Middle-School, meeting for a purpose which I would explain to them once the simulation began.
I then gave each participant a typed sheet on which the following information appeared:

Notes for school-based Curriculum Planning compenent of B.Ed. Year 3

Curriculum Development Course (Primary Faculty)
Greyfields Middle School

Built in 1898, Greyfields Middle School has ten traditional classrooms surrounding the one main central hall used for assembly, P.E. and school dinners.
The school has been rather 'formal' over the decades, and very 'succesful' in the now-abandoned 11-plus examinations (in a predominantly professional class catchment area), but it has changed considerably since the arrival, five years ago, of Ms/Mr.Green as headteacher. There is a measure of conflict between the 'old guard' in the staff-room and some of the teachers appointed since Ms/Mr.Green's appearance.

Staff:

Head	: Mr/Ms.Green (B.Phil)	
Deputy	: Cullompton:	'I believe in the old-fashioned virtues'. (Certificate)
	Smithson:	Interested in art and craft, and poetry (A.T.D.)
	Jones:	P.E. and school journeys (Certificate)
	Davidson:	Much influenced by Deputy Head (Certificate)
	Brown:	Keen on children's personal writing (B.Ed.)
	Somers:	Wants a return to 'bread and butter' subjects (B.Ed.)
	Driver:	Keen on projects (B.A. (O.U.))
	Kennedy:	Music and drama (L.R.A.M.)
	Pinner:	Remedial subjects (M.Ed.)
	Stone:	Maths and Science (B.Sc.).

Those taking part in the exercise had about a quarter of an hour to discuss who 'became' each member of staff. When there were not enough students present to make up the entire "staff", they had to assume that certain of their "colleagues" were absent.

The next stage was to ask them to write their "new" names in block capitals on a blank sheet so that could address one another properly.

At this point, I told them that I would take part in the simulation exercise myself, as their divisional educational officer, and that my name would be Mr. Brownlow. Once the exercise began, I would first have a private word with their 'headteacher', and then speak to them all. They would work on the 'agenda' for the meeting for an hour and I would be present most of the time for discussion and consultation. At the end of the hour, I would say goodbye as Mr.Brownlow, go out of the lecture room, and return a moment later as their lecturer, announce myself as such by saying my name, and ask each in turn to say his/her name. We would then conduct our post-mortem and de-briefing exercise.

The exercise

The 'headteacher' and I left the room and the exercise began. As 'divisional education officer', I explained to him/her apologetically that I had come on a rather embarrassing business concerning a mothers' complaints about standards of English in the school. I said that as I knew the school well, I had every confidence in the quality of the teachers' work, but that since the mother was visiting me on a formal basis in a fortnight's time, I would appreciate his/her chairing a discussion with his/her staff in whichthey would try to draw up a 200-word statement about the English language policy in their school.

We then went back into the 'staff room', and I repeated my apology and request to the assembled staff. I said that I would try to be as helpful any questions they might ask as I could.

Background: Altogether, over a period of four years I have conducted this exercise with a total of eleven separate groups, and intend to continue the process in my work in future years.

Part of the thinking behind the exercise has to do with questions about the degree of anxiety appropriate for educational enterprises of this sort. In the early '70's, I helped to conduct T-Groups, inter-group exercises and institutional residential events for trainee teachers with several of my colleagues, in which levels of resentment against 'authority' normally ran very high on occasion. My faith in such training events remains unaltered, but when participants are not able to 'resume normal relations' with their lecturers afterwards, difficulties arise.

In this particular simulation exercise I hoped that the presence of a 'sympathetic divisional educational officer' would keep the 'angry parent' at a comparatively safe distance, and make the 'teachers' feel that 'Big Brother' was on their side. Clearly, the situation was a far from comfortable one, but one similar to problems they might encounter in their later professional life (Auld, 1976; Ellis, 1976)).

The exercise (continued)

One question which arose in every one of the eleven groups was: "Whose class(es) are the children in?" My answer was always the same: "I believe that this parent is unreasonable and biased in her charges. It would lead to an invidious situation if I were to tell you the mothers' name. There is some evidence of personal problems for her at home and I shall do my best to reassure her without giving way to her imaginings".

The other most frequent question was: "What part of the work is she complaining about? Spelling? Punctuation? Handwriting?

Reading? Literature? Drama?" My answer was: "Her complaints are pretty general and pretty wild, but I think it would be fair to say that she is much more concerned with the mechanics of language (and they are very important) than she is with literature. And that shows, in my view (and it is a view I am sure you all share), a certain narrowness of outlook and understanding".

Comment

Another look at the description of the school and staff members will remind us of the wide range of views represented there.
In each simulated staff meeting, lively and vigorous discussion took place; - often the 'traditionalists' lined up against the 'hypermoderns'. At times the 'headteacher' had to intervene, and restore a measure of balance. It was gratifying to see the high level of responsibility shown by young men and women of twenty or so years in their roles as Middle School headteachers. That is not to say that all the other participants automatically demonstrated a limited, lopsided view. One older woman student who elected to be "Mrs.Somers" ("wants a return to 'bread and butter' subjects") showed a commonsensical middle-of-the-road attitude in all her discussions.

Author's over-view

Clearly my first professional concern as lecturer responsible for the Bachelor of Education degree Language Skills course in the University was to encourage these students (in their third year) to think imaginatively about English language policies in the Middle Schools for which they were being trained.
The de-briefing time was therefore doubly important. It was important (1) in bringing all participants back into the

'real' world, and (2) in providing an opportunity to look in a more intelligent way at the issues that the simulation exercise had raised.

De-briefing and assessment

Participants, during de-briefing, were often amused at the rigidity of some of the views they had been promulgating, and spoke with a good degree of understanding about the need for the imaginative use of discipline and the disciplined use of enthusiasm in all their work in Middle Schools. They expressed surprise at how quickly they had become involved in the debate, and how strong the feelings were that had emerged.

Many said that they had found it unexpectedly easy to articulate points of view, whether or not they were ones they genuinely held to be valid (Compare Power, 1977).
They felt that the approach through simulation to questions of curriculum development in English language teaching was preferable to the more formal system of lectures and lists of cources.
Only one student in four years declined to take part. She said she could not do it. I talked to her during the preparation time and offered her the option of remaining as an observer, or going off to the library to do some private reading of the Bullock Report (H.M.S.O.1974) which was an obligatory text for the course. She chose to do the later.
An interesting development occurred in one group too small to simulate the entire "staff". They decided that both the "headteacher" and the "deputy headteacher" were "absent from school". When they heard the nature of the task, they tackled it with goodwill, but said, just before the simulation ended, that, naturally, they could not let me have any document to take away without waiting for the approval of their superiors!

Post-script

In the university year just finished, I was able to work with groups for two two-hour sessions instead of one. The task I set for the second session, within the same format, was to ask the "staff" to modify their language policy statement (prepared in the first week) in the light of the Department of Education and Science's Assessment of Performance Units plans to test basic literacy and numeracy skills systematically in schools chosen on a representative basis throughout England each year, beginning in 1979. They were encouraged to look at this radical departure in central government attitude from the traditional system based on local independence and local control[1]. They were particularly concerned with the decision to make no attempt to assess performance in spoken English (it was said to be "too difficult"), and the effect the whole new plan might have on teaching and teachers.

Footnote

[1] This is not to say that no national testing of standards has occurred. From examples, since 1947, under government funding, the National Foundation for Educational Research has assessed the reading standards of children of various ages, and, more recently (H.M.S.O., 1978) a detailed report on primary education has been published, in which arguments about standards of literacy and numeracy are explored.

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Chapter 4:

Simulation/Gaming as a research tool.

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On the difficulties people have in dealing with complexity.

1 Introduction

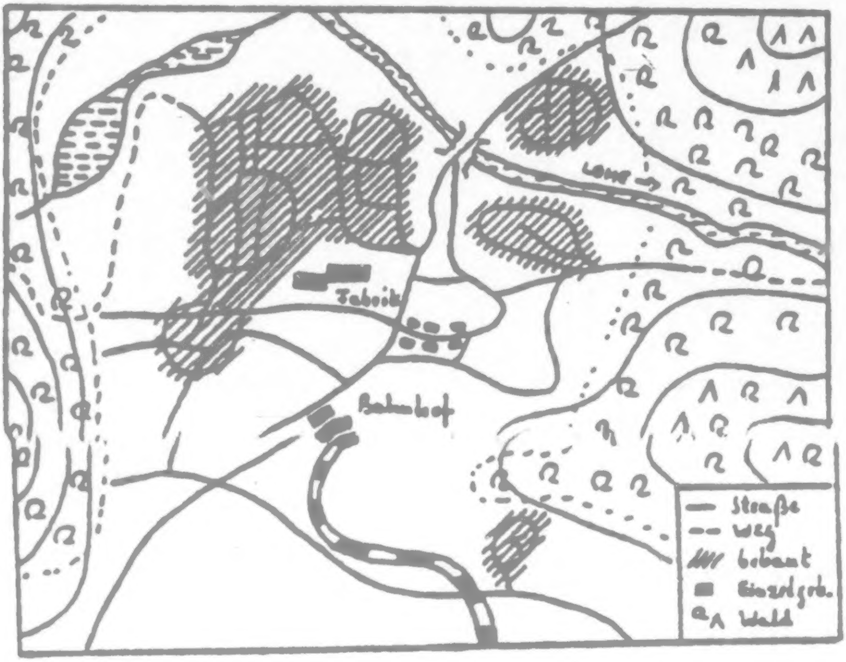
During times in which human living conditions quickly change, rigid norms cannot determine rules of conduct alone, as such systems of norms have a natural inertia and it is an arduous task adapting them to changing conditions.

During such times there is usually an appeal to the independence of the members of the group, to the ability of the "adult citizen" to express an autonomous opinion and to be responsible for making an individual judgment about facts and developments, about atomic power plants and roadways, thru-ways and economic relations. The vehicles of the autonomy, the individual responsibility and the coming of age is the human reason, the ability to make a judgment about things after reflection and critical analysis.

The ability or inability of human thinking to meet the requirements of very complex systems is the main theme of this lecture. In a series of experiments we have attempted to learn something about the attributes of human thinking in dealing with very complex systems. This report describes some of the results of our work.

Human thinking and action in very complex areas is not easy to analyse. In reality it drags on over long periods of time and is only casuistically observable; one does not know to what extent the results can be generalized and whether the results represent general laws of human behaviour.

We sought a way out of this difficulty by transféring complex environments to the laboratory. One can use computers to simulate reality by programming them to represent models of political or economical systems, for example. It is possible to define the social, psycholcgical, economical and ecological relations of a small city as a network of interrelations and then simulate this with a computer. The calculator acts then - more or less in accordance with reality - like a small town.



Ill. 1: the map of the town of Lohhausen

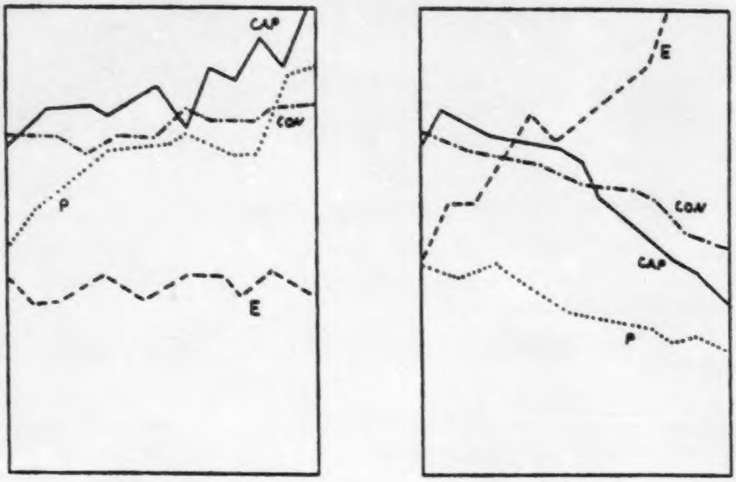
Such a simulation of reality makes it possible to analyse psychological processes in great detail and for many individuals, which can otherwise only be superficially observed in a limited number of people. In one of our experiments we gave subjects the task of ruling the fate of a small middle-European town named "Lohhausen" as "mayor". Fig.1 shows the map of Lohhausen.

The town had approximately 3500 residents and lived mainly from a municipal industrial enterprise, a manufacturing plant producing watches.

In addition, there was a city administration, of course, doctors' practices, retail stores and shops, a bank, schools, kindergardens, etc.. This system existed as a computer model. In this system there were many different measures possible. Subjects were able to influence production and sales policies of the city factory, to vary rates of taxation, create employment positions for school and kindergarden teachers, establish and lease doctors' practices, urge on housing construction, provide for leisure time arrangements, etc..

One could debate whether such a game situation really brings generalizable results. We have reasons to assume that in certain regards the results can be generalized. At any rate such a game situation challenges thinking in a way similar to real systems: subjects have to deal with a complicated system which at first is partly unknown, and of which they only have insufficient knowledge. The situation is not much different when citizens are asked to express an opinion as to the construction of atomic power plants or roadways.

Many subjects accomplish this task very well, others not as well. Fig . 2 shows the development of the town for a very good subject ("Konrad") and a very bad one ("Marcus").



"Konrad" "Marcus"

Ill. 2: The development of "Lohhausen" for a very good ("Konrad") and a very bad subject ("Marcus") with regard to some important variables. CAP = "capital", CON = "contentment", P = "production", E = number of unemployed peo

It is an interesting question, why some people apparently are able to deal with such complex structures without prior training, while others, in certain cases with relevant pretraining, only master the task in an unsatisfactory manner. I do not want to pursue this question at this time, however.

I shall now mainly be concerned with the mistakes of the bad subjects and I shall try to systematize these mistakes to find out the psychological background of the behaviour of the subjects. The cause for confining myself to the behaviour of the bad subjects lies in my opinion, that some general behavioral tendencies show up in greater clarity in the behaviour of the bad subjects than in the behaviour of the good ones. Therefore it seems to me more important, to consider the behaviour of the unsuccessful subjects.

We are now going to discuss some primary mistakes which nearly all subjects make as they begin, and then we shall revise especially the mistakes of subjects with poor performance.

2 Primary mistakes

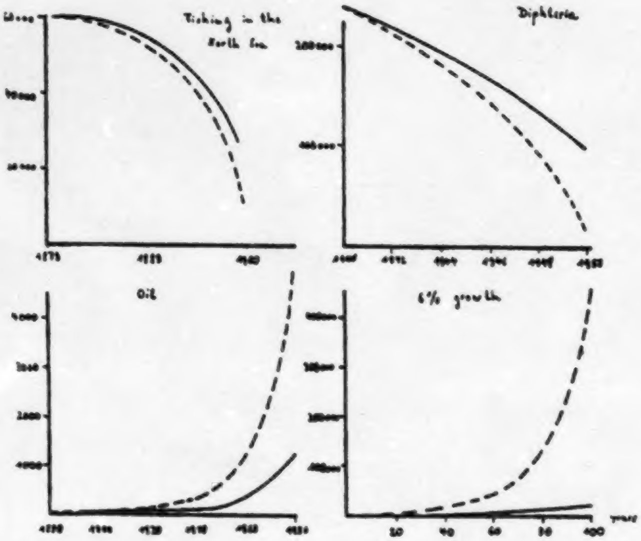
There is a series of mistakes which almost all subjects make when dealing with complex systems. Included are, for example

a. The insufficient consideration of processes in time:

When solving such complex tasks, most people are not interested in finding out the existent trends and developmental tendencies at first, but are interested instead in the "status quo". For example, they are not interested in the way in which city assets have developed in recent years, but rather the amount of money in the city treasury at the moment. This information is practically meaningless, however, without knowledge of developmental tendencies and their determinants. In connection with the judgment of processes in time it is also significant that almost all subjects have:

b. Difficulties in dealing with exponential developments:

For certain reasons, exponential curves are of great significance in all systems in which growth or decline appears. People have absolutely no intuitive feeling for processes which develop exponentially, although they are surrounded by such. The average rise in income developed during the last 25 years in the Federal Republic of Germany for example, expressed in DM value, according to an exponential function, the increase in the mineral oil consumption in the last 100 years likewise, the decrease in the fish supply in the North Sea the same, etc.. When subjects are asked to estimate such curves, something like the result depicted in Fig . 3 typically appears.



Ill. 3: **Average estimated values (————) and actual exponential curves (-------) for some exemples of exponential growth and decline.
Data from BÜRKLE & DÖRNER (1979)**

This implies concretely: someone who reads in the newspaper for instance that 6% economical growth is possible in the long run is not in the position to understand this piece of information. The dynamic and almost explosive acceleration which expontential curves display is assessed in a completely false way. This inability to deal with exponential functions when working with complex material causes unbelievable amazement and astonishment over developments which set in quite abruptly in the eyes of the subjects, but which in reality are precisely predictable at closer view.

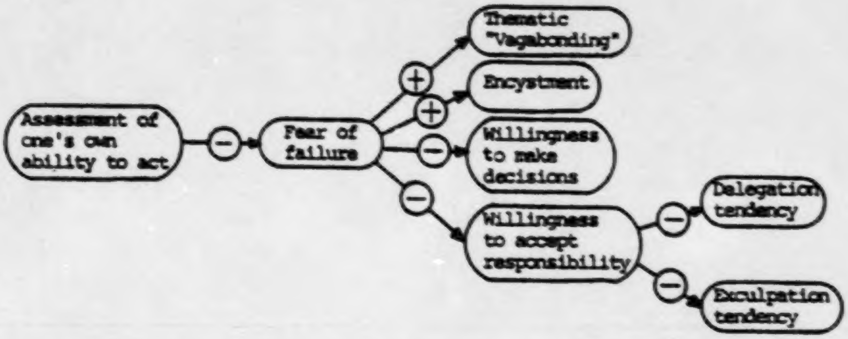
c. Thinking in causal series instead of in causal nets:

A third, quite general mistake is the tendency to think in causal series, not in causal nets. Subjects who are not accustomed to deal with complexity usually only see the aspired main effect of the measure, and not the side effects which also appear. There are not a few examples of this type stemming from the early days of policy-making involving aid to developing countries, for example, and not only in this area. The fact that the introduction of modern medical care not only reduces human suffering directly, but also helped to create famines and slums for millions of people indirectly by furthering a population explosion, was presumably not considered when planning these measures. People make these and other mistakes. Some can learn from them and adapt their thinking to the challenges of the situation, other do not succeed in doing this.

3 The characteristics of thinking of bad subjects:

It seems to us to be a characteristic trait of the thinking of bad subjects, to show a low assessment of their ability to act. There exists a statistically significant relationship between the self-assessment of the subjects and their performance (KREUZIG 1978). It is, however, not clear whether the selfassessment is low with the bad subjects a priori or whether the low selfassessment develops in the course of the experiment. We assume, that there exists a low self-assessment of the bad subjects a priori, which in a positive feedback-loop is weakened further by the experience of failure.

Some consequences of low self-assessment (resulting from data of STÄUDEL (1979) and REITHER (1979) are depicted in Fig. 4

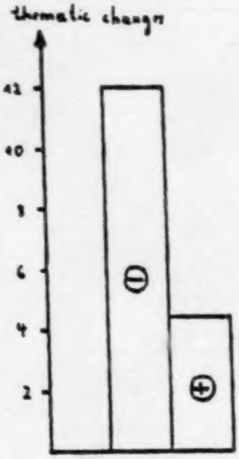

Assessment of one's own ability to act
−
Fear of failure
+
Thematic "Vagabonding"
+
Encystment
−
Willingness to make decisions
−
Willingness to accept responsibility
−
Delegation tendency
−
Exculpation tendency

Ill. 4 Consequences of the fear of failure.
—⊕→ implies a "positive" relationsship:
"if more ....then more" resp. "if less ....
then less". —⊖→ implies a negative relation:
"if more ....then leee...."resp. "if less .....
then more".

Failure despite efforts to get control of the situation threatens the individual. The continual failure of one's action in a certain area implies that one does not have control over this area. Continuous failure indicates a loss of control. One begins to estimate one's own ability to act as being very low. The loss of control implies fear; above all, a fear of a further loss of control , fear of failure, the consequences of which are:

a. Thematic Vagabonding:

This is manifested in the fact that during the experimental sessions individuals change the topic under consideration relatively quickly and often, without thinking a theme out to the end and ending it. People jump from one topic to the next, treating all superficially, in certain cases picking up topics dealt with earlier at a later time; they do not go beyond the surface with any topic and seldom finish with any. This intellectual vagabonding has already been superficially demonstrated (DÖRNER 1979) and we interpret it as escape behaviour. Whenever subjects have difficulties in dealing with a topic, they leave it alone, so that they do not have to face their own helplessness more than necessary. Fig. 5 depicts the average number of thematic changes of good and bad subjects during a 2-hour session.



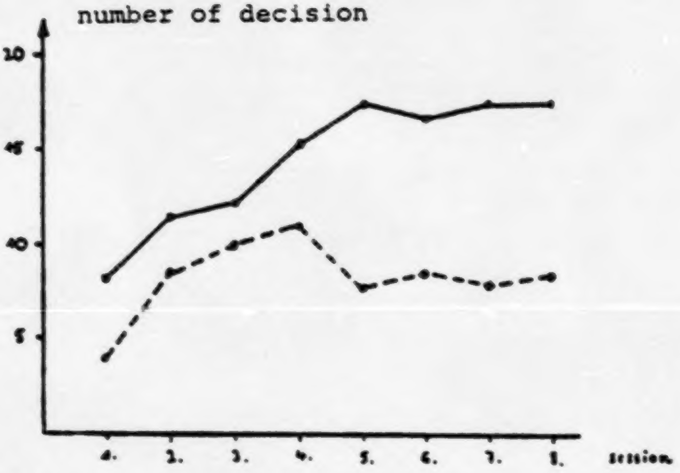
Ill. 5: The average number of thematic changes of good and poor subjects during a 2-hour session.

b. Encystment:

At first glance this tendency seems to be the opposite of the one mentioned above. Subjects stick to a subject matter, enclose themselves in it, treating small details very fondly and do not take on anything else. This tendency is only apparently opposite to the tendency to roam. In reality subjects enclose themselves in those areas which do not seem to offer them any difficulty. These are usually the least problematic and therefore unimportant areas. One subject from the Lohhausen experiment asked fondly about the family relations of the school children of a school class, while the pressing housing construction problem was left totally untouched (although it was known). Subjects "roam" in the face of difficulties, and enclose themselves when this is not the case.

c. Decreasing willingness to make decisions:

The number of decisions decreases. Fig. 6 shows this clearly. One sees here that the number of decisions made by poor subjects increases up to the fourth session, then sinks, however, to stagnate on a low level.



Ill. 6: Average number of decisions in each of the 8 sessions of the lohhausen-Experiment. (———) : good subjects; (-----) : poor subjects

In addition, subjects postpone the decisions to a later time; they begin to fear having to make decisions and try to avoid them. This is closely related to the:

d. Tendency to delegate:

Subjects try to shift decisions which they are responsible for, to other decisionmaking authorities. "The head of the housing department should worry about that!" one subject ordered after his efforts to finance housing construction were in vain. That the head of the department "housing" is unable to do anything without resources did not seem to be clear to the subject. The delegation tendency is closely related to the:

e. Exculpation tendency:

Subjects try to find external reasons for their failure in order to free themselves from responsibility. Many subjects expressed something like "You've intentionally programmed the system in such a way that it is not possible to succeed in dealing with it!" Others blamed the workers' laziness or the management's inability for the deplorable failure.

A situation which proves to be inaccessible to the efforts of the subjects, which becomes more and more uncontrollable with time, not only induces fear because it endangers the individuals self-confidence, but is also threatening because one does not know everything that can happen.

Such a situation is therefore not only a danger to the subjective estimation of one's own competence; the danger extends and attacks the physical intactness and existence in some cases. (Our game situations were naturally harmless in this

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respect; we presume, however, that general situations which elude one's own control is regarded as detrimental in quite a general way and not only harmful in respect to the individual feeling of well-being).

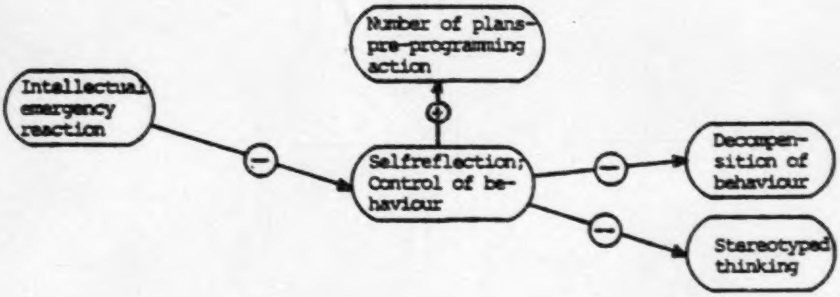
A critical situation therefore causes an intellectual emergency reaction. The entire system of action becomes adapted to a quick readiness-to react. A quick readiness to act is hindered by an intellectual level which is too high.

Searching for new possibilities of action is out of place in a dangerous situation; it takes up too much time. It is better to employ the secure "programmed" inventory of reactions which is available from acquired stimulus-reaction sequences. In extreme cases "thinking" becomes totally eliminated in danger situations. One turns into a reflexive being which acts "automatically"; anyone who has been in an extremely dangerous situation, for example while driving, can confirm this.

The sinking of the intellectual level, which we observed in our experiments whenever subjects lost control of the situation, is the result of such a general emergency reaction, we believe. One observes the following details:

a. Reduction in the number of self-reflections:

Phases of self-reflection, in which subjects recapitulate and critically analyse their own past action and thought, are a great significance for changing and improving one's own thinking. The number of such elements making up the cognitive process decreases under conditions of failure. This indicates we believe, that a certain cognitive emergency reaction occurs. Closely related to a decrease in those phases of the thinking process, which contain a critical self-analysis of the procedure employed, is a series of other symptoms, depicted in Fig . 7 . It comes, for example, to an

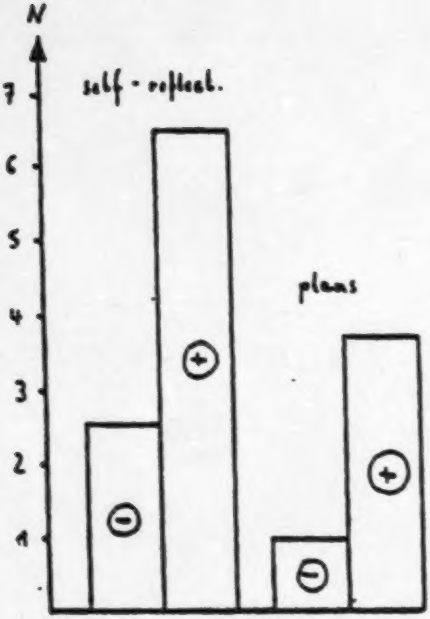

Number of plans-pre-programming action
Intallectual emergency reaction
+
−
Selfreflection; Control of behaviour
−
Decompensition of behaviour
−
Stereotyped thinking

Ill. 7: Consequences of reduced self-reflection. Further explanations to be found in the text.

b. Reduction in the number of plans:

Subjects usually "program" their behaviour more or less by means of "plans". They say: "First I must do this, then that, - if that is the case, then I must take care of...", etc.. These programs are a rather important part of the cognitive process, as they quarantee a systematic progression of thought; accordingly, their temporary loss results in a less coherent cognitive process. Fig. 8 shows the mean number of self-reflections and plans for good and poor subjects.

Furthermore, it implies the decompensation of thinking, the dissipation of thinking in disconnected individual actions. (see REITHER 1979). The fact that this dissipation of thinking actually occurs is supported by the fact that thinking becomes increasingly characterized by an:



Ill. 8: The mean number of self-reflections and plans for good and poor subjects.

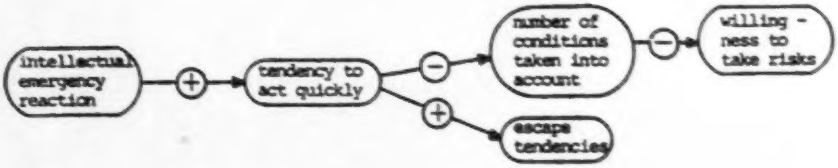
c. Increasing stereotyping:

With an increasing rate of failure it is possible to observe that subjects become less and less aware that they are following the same thought sequence once again. It occurs more and more frequently that subjects think over the same sequence as before all over again. The fact that they do not notice this points to a decreased amount of self-control. A further index for the decrease in self-control is the

d. Decreasing control over the realization of plans:

We have already shown that the number of programs represented in the number of expressed plans clearly sinks when subjects tend to face failure. If one compares the relative number of realized intentions of good subjects to the corresponding number of subjects who tend to fail, one can see that the number of realized intentions clearly sinks in relation to the number of suggested plans. That implies that subjects facing failure do not even check whether those plans which they themselves have considered, have been realized.

The cognitive emergency reaction which we have described above does not only involve lowering the intellectual level. In addition, it is important to master the situation. A dangerous situation must be quickly overcome; we presume that for this reason the emergency reaction creates a readiness for quick action. This tendency has a series of consequences which we have depicted in Fig. 9. It is not possible to act quickly when one takes too many conditions for one's own action into account. The intellectual emergency reaction causes a reduction in the number of conditions considered before decision-making. This has consequences.


intellectual emergency reaction
+
tendency to act quickly
−
number of conditions taken into account
−
willing - ness to take risks
+
escape tendencies

Ill. 9: Consequences resulting from the tendency to (re) act quickly. Further explanations to be found in the text.

Thus observable is an:

a. Increase in risky behaviour:

Subjects are prepared to put up with a greater number of risks if they have previously experienced failure. A tendency to master the situation "at any price" seems to appear. Closely related to the increase in risky behaviour is the

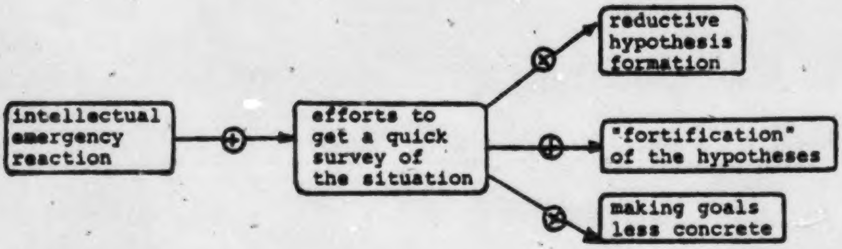
b. Increase in the number of violations against rules and regulations:

The more subjects are exposed to failure, the less their willingness to stick to given rules or regulations. One can generally say that subjects' behaviour becomes more "absolute". Peripheral conditions for limiting behaviour to certain forms are increasingly disregarded. It is no longer of interest whether or not a certain type of behaviour is allowed or forbidden; the only important thing is whether or not it can help to achieve the aspired goal. It would probably be very easy for the unsuccessful subjects in our experiment to accept the sentence "The end justifies the means". It is therefore not surprising, that under these conditions it is also possible to report an

c. Increase in the tendency to escape:

One can clearly observe that the number of attempts to escape from the situation increases. This is expressed for example in the fact that subjects facing failure tend to lengthen their pauses to a greater extent or begin to talk with the experimentator about topics having nothing to do with the experiment. It is not possible to decide whether the tendency to escape really is due merely to the intellectual emergency reaction, or whether the attempt to avoid failure is an additional factor; one can assume that both are important.

It is not only important to act in any way in a situation; it is important to behave adequately for the respective situation. Therefore, it is important to have a clear picture of the situation. One must know the character of the situation to be able to act wisely. It is characteristic of complex situations that one does not have complete knowledge of the situation, but rather that one must acquire this information while acting. An additional cognitive task for a complex situation is thus the formation of hypotheses. One can observe subjects' characteristic deformations under the influence of failure with respect to the formation of hypotheses, which we summarize in Fig. 10.

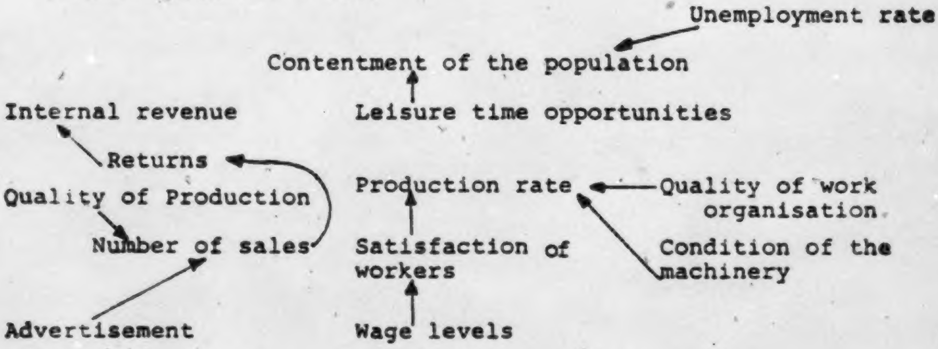

intellectual emergency reaction
⊕
efforts to get a quick survey of the situation
⊗
reductive hypothesis formation
⊕
"fortification" of the hypotheses
⊗
making goals less concrete

Ill. 10: Results of the attempt to quickly get a survey. Explanations in the text.

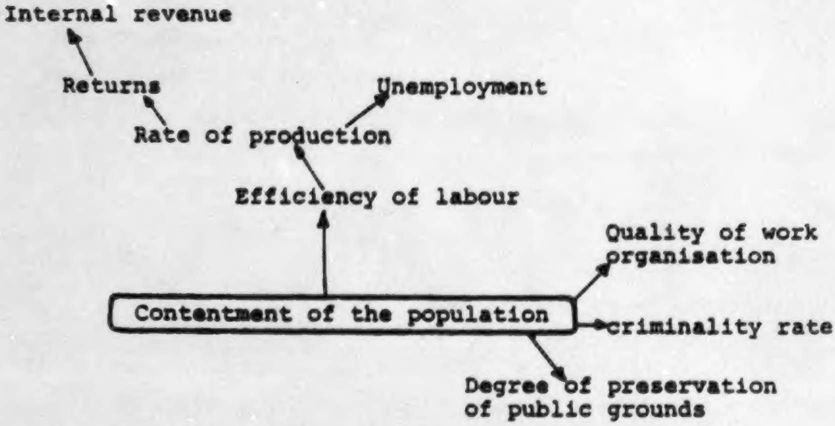
a. Hypothesis-formation becomes increasingly more global:

This fact implies that subjects try to reduce more and more characteristics to fewer and fewer causes. A differentiated system of individual hypotheses, which one - for lack of knowledge - neglects to integrate, when an integration does not simply result by itself, yields to a rough, radially organized general hypothesis, in which all "phenomena" are attributed to a central cause. Fig. 8 shows this development:

Subjects usually make partial hypotheses about existing relationships on the basis of past experiences, which do not necessarily become integrated. Fig. 11 a shows an example of this. Under conditions of failure the pressure to integrate and build a general hypothesis apparently rises, which takes on a reductive form, as depicted in Fig. 11 b. All facts are attributed to a central motive here ("contentment of the population"). Such total hypotheses are also well-known to us from other sources, moreover, and take on the form of the following examples: "Only the profit greediness of the big business and the multis...", "Only the subversive activity of the imperialistic Soviet Communism...", "Only the international Judaism...", etc.



Ill. 11 a "Normal" network hypotheses


Internal revenue
Returns
Unemployment
Rate of production
Efficiency of labour
Quality of work organisation
Contentment of the population
criminality rate
Degree of preservation of public grounds

Ill.11 b reductive hypotheses

Reductive hypotheses are very attractive for the simple reason that they reduce insecurity with one stroke and encourage the feeling that things are understood. (They can even be right-why not, that can be proved. The probability is rather low, however, that organic structures are monocausal and radially organized).

The degeneration of hypothesis formation is accompanied by a deformation of the methods of testing the hypotheses. The result is a

b. "Fortification" tendency:

The strictest way to test the validity of an hypothesis is to attempt to disprove it. Subjects do not display this tendency at first; they do not look for disproof, but rather for confirmation. In the course of the experiment good subjects change to a strategy involving refutation of their hypotheses, whereas poor subjects continue looking for confirming information. This is a dangerous tendency and is the same as an "entrenchment" of previously formed hypotheses. By ignoring or rationalizing information which could refute an hypothesis, it is possible to maintain each hypothesis as long as desired. This can be observed by unsuccessful subjects.

A further effect of the tendency to deal quickly with a situation is the fact that:

c. Goals become less concrete:

At the beginning of the experiment, subjects mostly pursue very concrete goals,which are very precisely specified. This picture changes with increasing failure. One can also keep the number of proposed goals lower by being abstract as many concrete goals can be subsumed by one abstract one. On the other hand, the ability of concrete goals to guide action decreases as goals become more abstract.

For instance the goal: "Increase sales/returns from the city watch factory!" can function as a directing force. It is a different story with the goal "Increase residents' happiness!" The assertion of this goal is indeed praiseworthy and certifies the individual's humanitarian intentions; it is rather difficult, however, to deduce concrete measures from this goal.

Both a decrease in the amount of self-control and the building of less concrete goals are responsible for the fact that in the face of increasing failure subjects' general behaviour becomes increasingly decompensated and decomposes more and more into unconnected individual actions. (REITHER 1979).

4. Conclusions

The total sum of tendencies brewed here together apparently make up quite a troublesome mixture. Although each tendency taken alone does not always seem to be an unreasonable consequence to the situation, taken collectively they result in a combination which gives occasion for consideration. This becomes clear upon intensifying the depicted tendencies somewhat.

In the extreme situation the tendency to become less willing to make decisions and the tendency to shift responsibility, for example, change to a state of indecisive semiconsciousness, in which the person lets himself be lethargically drifted at random, as it were, standing next to or outside of things. This state is by all means compatible with the fact that the same person, upon being urged to act, tends to resort to extremely hard measures and to take extreme risks at the next moment, not feeling responsible for any and all negative consequences.

It is not necessary to look for examples of such conglomerates of lethargy and extreme riskiness accompanied by a simultaneous feeling of irresponsibility in the bunker of the Chancery of the Reich in 1945; they are displayed by our subjects. In the face of a light drop in production in the city watch plant one subject fired 40% of the entire staff and then proceeded to explain, almost in the same breath, that the decline of the watch factory had been pre-programmed and was therefore incessant. This belief in pre-destiny did not stop our subject in any way from considering shooting those workers whose machines were defective for reasons of sabotage, however.

Our subjects did not display such drastic behaviour tendencies as a rule. Nevertheless, they appeared 4 - 5 times by approx. 50 subjects, which surely shows that a potential for such behaviour is not rare.

More important than the consideration of such individual cases is the fact that such behaviour patterns are in no way isolated phenomena, only explanable with the aid of psychopathological or sociopathological categories, or by assuming psychoanalytically conceivable distortions in the early childhood. Such behaviour is on the contrary nothing more than especially crass distinctions of behaviour tendencies, which appear in quite normal, intelligent individuals in statistically significant frequencies.

Let us turn to other possible consequences of the behaviour tendencies described above: is it not possible to deduce from the tendency to shift responsibility and the exculpation tendency, along with a simultaneous reduction in the willingness to act, the existence of an increased willingness to subordinate to the leadership of individuals or institutions which claim or verify that they have the correct plan of action? We believe that this is in accordance with the depicted behavioral tendencies, especially when one additionally considers the tendency to build reductive hypotheses, which we have described above. Reductive hypotheses are those which explain the phenomena of an area in terms of a single motive.
The tendency to shift responsibility and the fear of acting, coupled with the simultaneous feeling that one must act, and the tendency to build reductive hypotheses, build, in short, a potential which induces the acceptance of totalitarian theories and ideologies coupled with a simultaneous willingness to resign from acting and let other (more competent?) institutions do so.

If one includes the tendency to test hypotheses exclusively by verifying them, i.e. to exclude all falsifying information, then an additional ingredient appears in the cocktail described thus far, namely the tendency to dogmatically entrench one's own opinions, in short, the tendency to become obstinate and dogmatic.

It must be stressed that all these conclusions are nothing more than - not quite so far-reaching-generalizations from generally observable behaviour tendencies. We therefore believe that certain deformations and degenerations of reason are to a certain extent natural effects of general human behaviour patterns. We shall conclude our statement with two general conclusions:

Many psychological and sociological theses have been postulated as to the causes of war, atrocities, crimes and other evils of history caused by human hand. Ambition, fanaticism, demoniacal behaviour, revengefulness, criminal dispositions, evilness, and racial and class differences are cited. The fact that another trigger could be the simple inability to deal with complexity, which leads to failure, is seldom discussed. It can be shown, I believe, and that is the first conclusion, that even when simple, well-meaning inability begins a causal series, extremely brutal actions can result in the end.

As to the second conclusion: one tends to localize and individualize the perversions of world history, which the NS-discussions triggered by the Holocaust-film in Western Germany clearly demonstrate, i.e. to attribute them to certain local conditions or to the corruptness of certain groups or individuals. Our results show, however, that tendencies to perform extremely cruel and brutal actions may result from the inability to deal with complexity, which in addition can easily be generated by many individuals, quite independent from the respective local conditions.

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Political attitudes and political behavior in international crisis - a simulation study of decision-making.

1 Introduction

This is an extremely short and edited summary of the researchreport itself, which has been published in Dutch 1). An abridged English version will be published later. This summary only contains (1) a short survey of the whole report, and (2) some points that are relevant for discussion.

2 The problem

The question whether attitudes can predict behaviour has been a research problem for decades 2). More specifically, the question is under what circumstances or conditions attitudes have a decisive influence on behaviour. In theory, attitudes and situations are regarded as the two determining factors. It still remains unclear what influence specific attitudes in a specific situation have on behaviour. The relevant question seems to be the specific one. It can be assumed that the influence of attitudinal and situational variables can differ greatly, depending, for example, on the strength of the attitude or the situation, or, more specific still, the level of abstraction of the attitude (some attitudes contain very precise indications as to how to behave in a situation, others are so vague that even conflicting kinds of behaviour could arise from them).

The most relevant attitudes for peace research, no doubt, are the attitudes concerning peace, war and violence. The most relevant behaviour is of course the political decision making, referred to in literature nearly always as "pacifistic" of "militaristic". The accompanying assumption is most of the time that "pacifists" would have made the world more peaceful ("full of peace") than their counterparts, or even the people who in reality take the relevant decisions. But from the theory about the attitude-behaviour relation it is not at all clear that this would indeed be the case. Pacifism, in this context, could be understood as a consistent set of ideas and opinions on how to behave in international relations, in decision-making on war and peace, and towards the use of violence in general. The political behaviour which is most relevant in the same context seems to be the decision making in situations of crisis, where decisions are taken on the use (or non-use) of military forces in international relations.

3 The research design

It was clear that it would be impossible to find answers to the aforementioned problem by the usual and orthodox means, such as interviewing political decision makers, analysing the contents of their memoirs, or even studying their biographies. This could have been done, but it would only have produced a lot of uncomparable data on very different decisions, in different situations, by people about whose attitudes only assumptions could have been made. On the other hand, psychology provides the technique of scaling attitudes, and in the last decades the simulation technique has been developed in the social sciences, particularly in peace research 3).

Therefore a research design was developed in which a number of people had to be selected for their high/low scores on a pacifism/militarism attitude scale beforehand. Then these people would be appointed in decision making positions in one nation in an internation-simulation model. The decision making positions in the other countries were given to dummies, who were playing a scenario in which subsequent crises arose. The political behaviour during the simulated crises could then be analysed afterwards, and comparisons could be made with the attitude-scores.

In literature, however, an interesting and potentially intervening variable was discovered, referred to as "political cognitive complexity" 4), which came up during the analysis of the possible differences in the perception of the situation between subjects with the same attitude score. "Cognitive complexity" is defined as "the capacity to construe behaviour in a multi-dimensional way". A more cognitively complex person has available a more differentiated system of dimensions for perceiving other people's behaviour than does a less cognitively complex person 5). It was assumed that this variable would modify the direct relation between attitudes and behaviour. The reason for this hypothesis was the assumption that a high level of complexity would lead to a multidimensional analysis of the perceived situation, which in turn could lead to the discovery of more behavioural alternatives in the same situation. Subsequently, the research design was changed slightly, in order to build in this variable. In this way, four different groups of experimental subjects were formed:

	Political complexity	
	low (Simple)	high (Complex)
Pacifists	PS	PC
Militarist	MS	MC

In order to get sufficient data for analysis, at least five experiments had to be conducted within each group.

4 Research

After the construction and validation of a pacifism/militarism scale (15 items), a political cognitive complexity scale was developed and validated as well. After that was done, the pacifism/militarism scale was administered to about 1200 students from six different institutions for higher education. The people with the highest and the lowest scores were invited to participate in a simulation of international relations. Those who accepted were asked to fill out the complexity scale. On the basis of the known scores on both scales the four groups were formed. The simulation model consisted of four countries: two "super powers" and a former super power now divided into two independent nations, each of which was allied to one of the super powers (in fact an USA-USSR-Germany model). The experimental nation was called "Western Divisia", being one half of the divided country. There were four decision making positions: PM, Foreign Affairs, Defense, Finance. This "government" was formed from a homogeneous group of experimental subjects. The governments of the other countries were, without the experimental subjects knowing this, manned by dummies who acted according to preprogrammed instructions (a "scenario"). This scenario, which was kept exactly the same during all the experiments in order to create the same situations, was prepared in accordance with literature so as to contain all the relevant crisis elements: threat, time, surprise. ("...a crisis is a situation that (1) threatens high priority goals of the decision making unit, (2) restricts the amount of time available for response before the decision, and (3) surprises the members of the decision making unit"). (6). The model made it possible to conduct three experiments simultaneously. Each experiment simulated a period of fourteen years. As one year took exactly half an hour, it was possible to introduce subjects in the technical difficulties of the model and to conduct the experiment all in one day.

From the flow of accumulated data the analysis was concentrated on arms expenditures, government declarations, written communication to other countries, and the kind of information asked from other nations. Furthermore, for each year the perception of the international situations (especially of threat) was measured on an individually administered scale; the scores of this scale were used (among others) as a means to control the effects of the scenario. Totally, 26 simulation-experiments were conducted (MS 5, MC 6, PS 9, PC 6). The whole simulation period of 14 years was subdivided into four periods, of 3, 4, 4, and 3 years respectively. In the first period there was no threat at all, except some indications of a cold war situation; the second and third period were characterized by increasing threat, and the final period by realisation of the threat. In year 10 for example, Eastern-Divisia, which (according to the scenario) had taken the initiative in secret negotiations on unification, was militarily occupied by its super power "ally", and only two years later Western-Divisia's own super power ally collapsed economically and militarily.

5 Results

5.1 The first central hypothesis was that pacifists will have a significantly lower level of defense-expenditures than militarists. Statistical tests yielded that this hypothesis was confirmed for the whole 14 years.

5.2 The second central hypothesis was that the variable "political cognitive complexity" would modify the relation between (political) attitude (i.c. pacifism/militarism) and political behaviour (i.c. decision making in crises), and, more specifically, that there would be a significant difference between the defence policy and defence expenditures of "simple" and "complex" pacifists, This hypothesis was also confirmed for all of the periods. In the last three years however the "simple pacifists" reversed the trend of their defence expenditures slightly, responding to the threat; the "complex pacifists" hardly seemed to feel the need to do this, regarding their defence posture. The change in the trend of the simple pacifists was, however, not significant. The same test was applied to the militarist groups. The difference in defence expenditures between simple and complex militarists never became significant.

5.3 The third central hypothesis held that defence expenditures would increase in response to increasing threat, which is in a way very trivial to find confirmed. The interesting results however concern what happened in the four groups individually. The hypothesis held for both militarist groups, but the majority of the "simple pacifists" groups decreased their defence-expenditures with increasing threat. (The scale measuring perception of threat confirmed that this was not due to a misperception).
The mirror-hypothesis that pacifist groups will decrease their defence expenditures with increasing threat was confirmed for the PS group, but not for the PC group.

6 Discussion

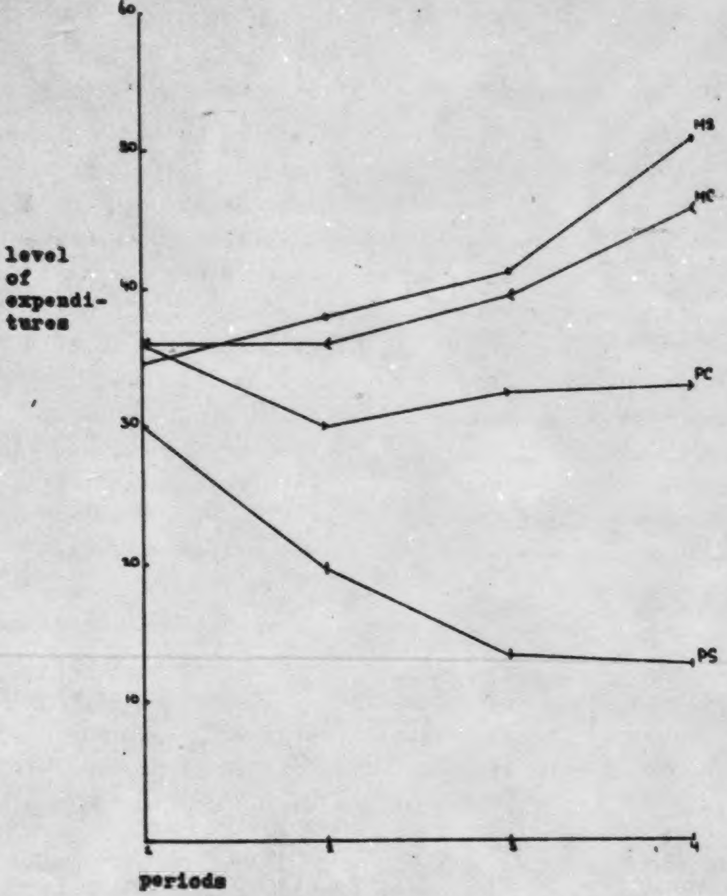
6.1 Mostly simulation experiments in international relations have been used for educational or heuristic purposes; in this experiment, however, the technique was used in the first place for testing hypothesis. This seems to be of some importance. In reality it is not possible to duplicate or triplicate situations and events in order to compare the effects of different policies, originating from different perceptions of reality or different opinions on how to achieve political goals. This was, of course, the main reason for using laboratory-research at all, but so far the application of simulation techniques in the social and political sciences has not been developed sufficiently to permit advances far beyond the orthodox insights and other results of history writing and armchair theorizing.

6.2 The relevance of the results should be judged against other findings, particularly in the field of attitude theory in psychology. The results concerning the "political cognitive complexity" seem very interesting for peace research and the study of international relations in general. It is interesting to note the behaviour of both "complex" groups (for example in figure 1).

They do not differ much in their behaviour, and in all behavioural tests the "simple" groups differ most. This could contribute to an explanation of the phenomenon of armsracing and armaments policy in general, which seems to continue in every period (in reality!), in every country, independent of the verbally pronounced declarations of intent from aspiring decision makers during election campaigns, or even in office.

In the first place it says something about their possible attitudes: these attitudes could be as extremely pacifistic or militaristic as the attitudes of the people who were

Figure 1



defense-expenditures

of "simple militarists" (MS), "complex militarists" (MC), "complex pacifists"(PC), and "simple pacifists" (PS)

(percentage of national income)

selected to participate in the experiment. In other words, there is no reason to assume that the political and social structure of societies in general permits only "militarists" to acquire politically important positions. In short: the level of political cognitive complexity is perhaps more important for political decision making than the content of the political attitude (this statement does not include the assumption that this would explain everything about other factors, of course, such as bureaucratic procedures, or the influence of specific interest groups, etc.). In the second place it says something about the "behavioural alternatives" as discovered in the existing situation by politicians. To them, there seems to be no other way to promote peace than to increase armament levels, and the price to pay for a "disarmament" agreement is mostly an increase in defence budgets and armaments. (For example: SALT II will probably be bought by a 3% increase of the USA defence budget over the next years, and the 30 billion dollar MK-system to start with, of course). If this conclusion is accepted, peace research could try to develop other "behavioural alternatives" with first priority.

6.3 This experiment could lead to the enormous misunderstanding that there is no effective "pacifist" policy against increasing military threat (as in the scenario used in this experiment). The policy pacifists generally tried to conduct in the experiment, was doomed to fall, as they played against a preprogrammed scenario. In this simulation, it could not possibly work: the other nations did not react to pacifist initiatives and proposals by the pacifist decision makers in Western-Divisia; they simply acted out the scenario, according to which they had to ignore all kinds of pacifist policy. But that does not say a thing about reality.

One of the other uses of such simulation experiments could be the testing out of possible "behavioural alternatives", as proposed by (advanced) peace research. For example, "Graduated Response in Tension" (GRIT) as proposed by Osgood in the sixties, could have been tried out in different settings of such simulation experiments - as could have been done with all other proposals and policy intentions, varying from unilateral disarmament to (on the other side) the acquirement of a first-strike capacity (which, according to the SIPRI Yearbook of 1979, is almost reached by the United States).

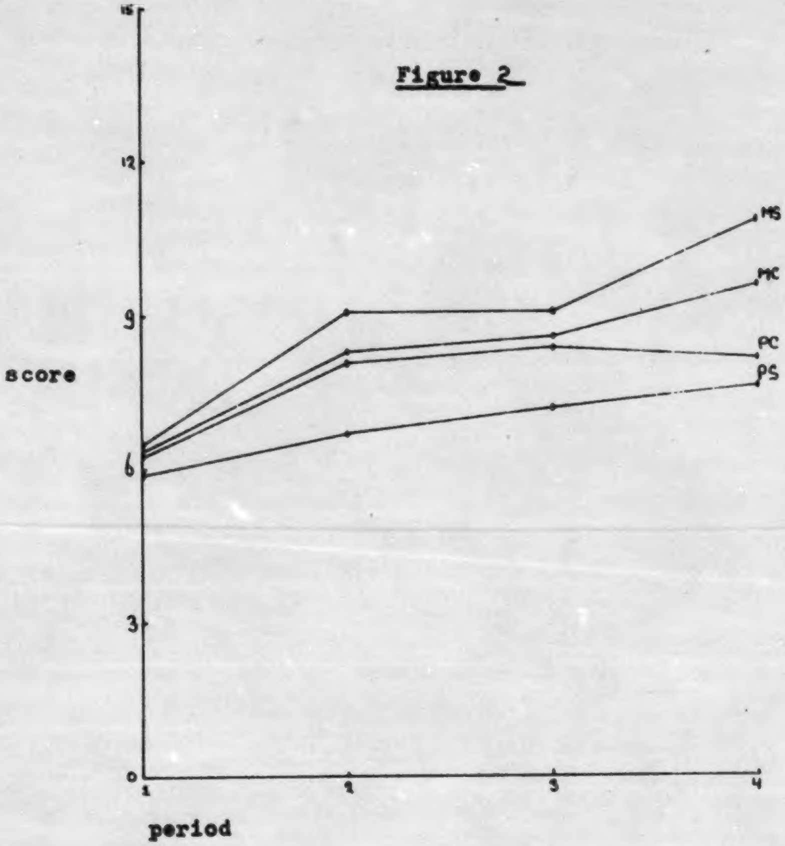
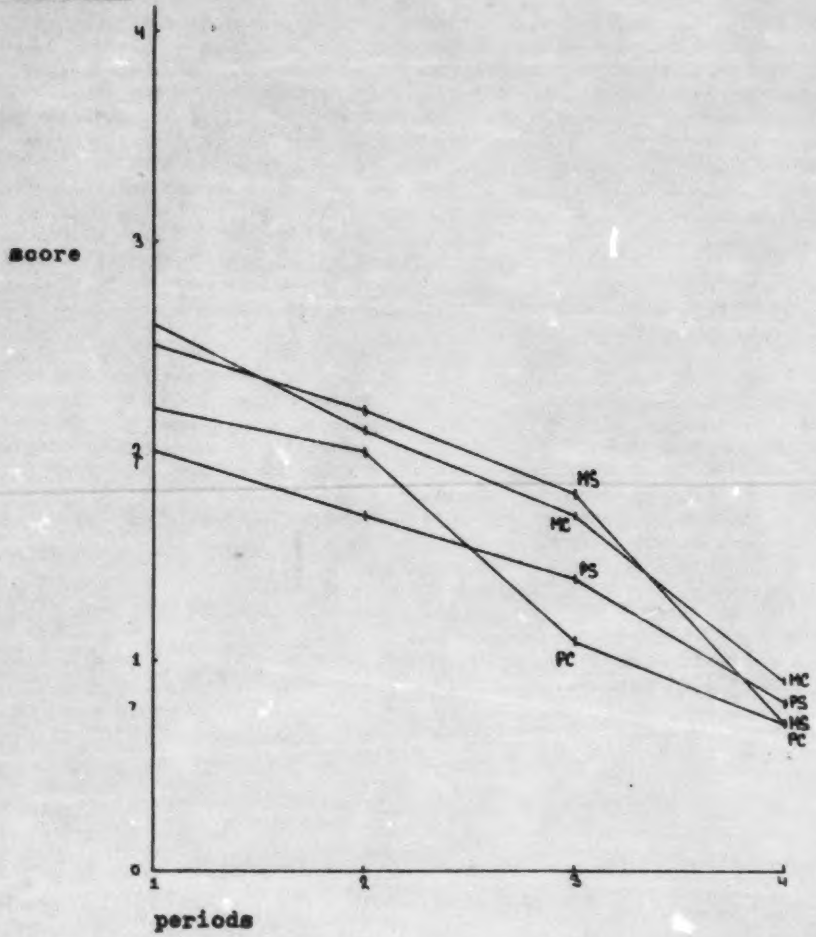


Figure 2

Declaration
of intent, as found in governmental papers, especially concerning the increase or decrease of defense-expenditures (sumscore of three judges who independently analysed the papers).
A higher score corresponds to the intent to raise the level of defense-expenditures.

Figure 3



Perception

of the international situation-especially:threat-over the periods. Score 0-4; a more threatening situation corresponds to a lower score.

Notes

1 Hylke Tromp - *Politieke opvattingen en politiek gedrag in internationale crisissituaties*. Groningen, Polemologisch Instituut, 1976.

2 For example in the work of I. Deutscher, who summarized the results of research as follows:
"It has been observed that trade union members talk one game and play another, that there is no relationship between college students' attitudes toward cheating and their actual cheating behavior, that urban teachers descriptions of classroom behavior are sometimes unrelated to the way teachers behave in the classroom, that what rural Missourians say about their health behavior has little connection with their actual health practices, and that the moral and ethical beliefs of students do not conform to their behavior. It has also been reported that Kansans who vote for prohibition maintain and use well-equipped bars in their homes, that small-time steel wholesalers mouth patriotism while undercutting the national economy in wartime, that employers' attitudes toward hiring the handicapped are not reflected in their hiring practices, and that the behavior of mothers to their children is unrelated to their attitude toward them. If it were possible to observe bedroom behavior, I wonder what would be the relationship between Kinsey's survey results and such observations".

3 One remembers, for example, the work of Guetzkow and others, and the papers John Raser presented to IPRA. Independently a somewhat different model of international relations was developed in Groningen.
P. Boskma; H.W. Tromp - A report on explorative experiments with simulation models of international relations and on the effects of participation. *IPRA Proceedings*, Assen, 1970, and
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4.3 Dr. H. A. J. Struyker-Boudier and ir. R. Min, Department of Pharmacology, University of Limburg, Maastricht, The Netherlands.

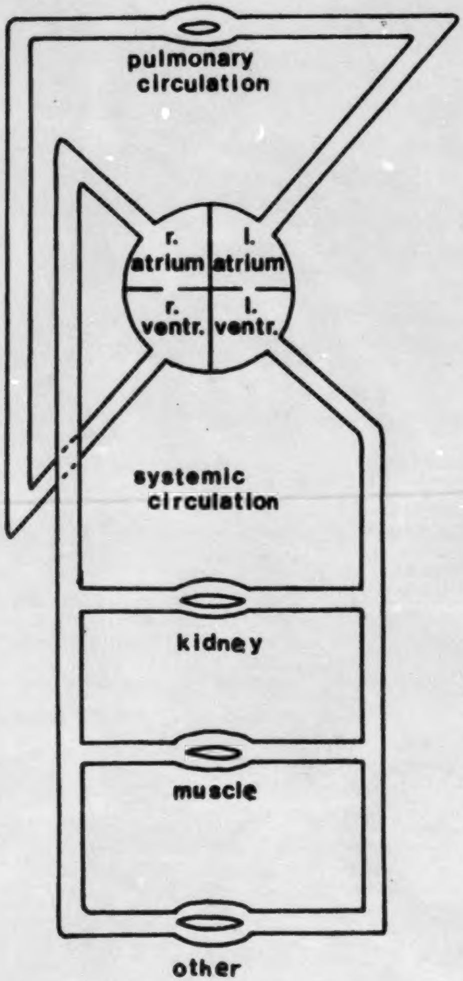
Computer simulation of the cardiovascular system: A research tool for the study of the pathogenesis and therapy of high blood pressure.

Introduction

Computer modelling and simulation are becoming increasingly important tools in biomedical research. Computer simulations in this respect are always based upon the use of a mathematical model of a biological system or process. A mathematical model of a system or a process transforms relationships obtained by experimentation into unambiguous mathematical relationships. If the mathematical relationships are written in an appropriate computer language a computer model of the biological system or process can be created. Such models can be used for computer simulations by changing one of the system parameters and observing the effects as presented by the computer output. In this way computer modelling and simulation provide a tool for the quantitative analysis of hypotheses or theories.

1 The cardiovascular system

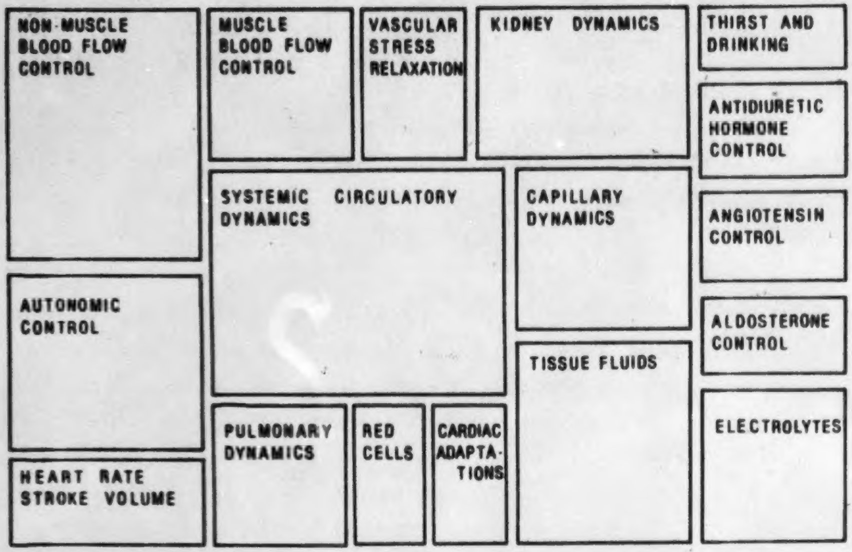
One of the areas in biology and medicine where computer simulations are used frequently is that of the cardiovascular system. The cardiovascular system takes care of an adequate blood flow through each of the organs in the body. Thereby it delivers oxygen and nutrients to the organs and removes waste products. Each organ has its own specific functions that require a specific control of its blood flow. Flow through the brain, for instance, determines the amount of carbon dioxide in the brain.



figuur 1

Since this amount needs to be kept between close limits for normal consciousness, blood flow through the brain has to remain very constant. On the other hand, in muscle the increased oxygen need during exercise may increase blood flow 20 fold from its value during rest.
Since the blood flows parallel through the organs, it is clear that the cardiovascular system needs to be controlled very well to achieve a proper distribution of blood flow through each organ.

A number of factors contribute to this control.
First, the cardiovascular system consists of structural elements with different properties: the heart is a pulsatile, four-chamber pump that supplies the force to propel blood through the lungs and the peripheral circulatory system. The arteries thereby contain a volume of blood with a relatively high pressure. The amount of blood flowing from the arteries into the capillaries of each organ is determined by the resistance exerted by the arterioles. The veins contain the majority of the volume of the blood and the venous return of the blood in its turn is one of the primary controllers of the amount of blood pumped by the heart per unit of time (the cardiac output).
In addition these intrinsic properties of the cardiovascular system, extrinsic control mechanisms contribute importantly to overall cardiovascular regulation. These include the autonomic nervous system, several endocrine mechanisms such as the renin-angiotensin system, antidiuretic hormone and aldosterone, several mechanisms that control the amount of fluid and electrolytes in the body, such as capillary fluid exchange and renal fluid and electrolyte excretion. The reader may find a detailed discussion of each of the control mechanisms in several physiological handbooks and review articles (Guyton et al., 1972, 1974; Struyker-Boudier and Rahn, 1979). Figure 2 contains a block-diagram with the major relationships between the different elements of the overall cardiovascular control system.



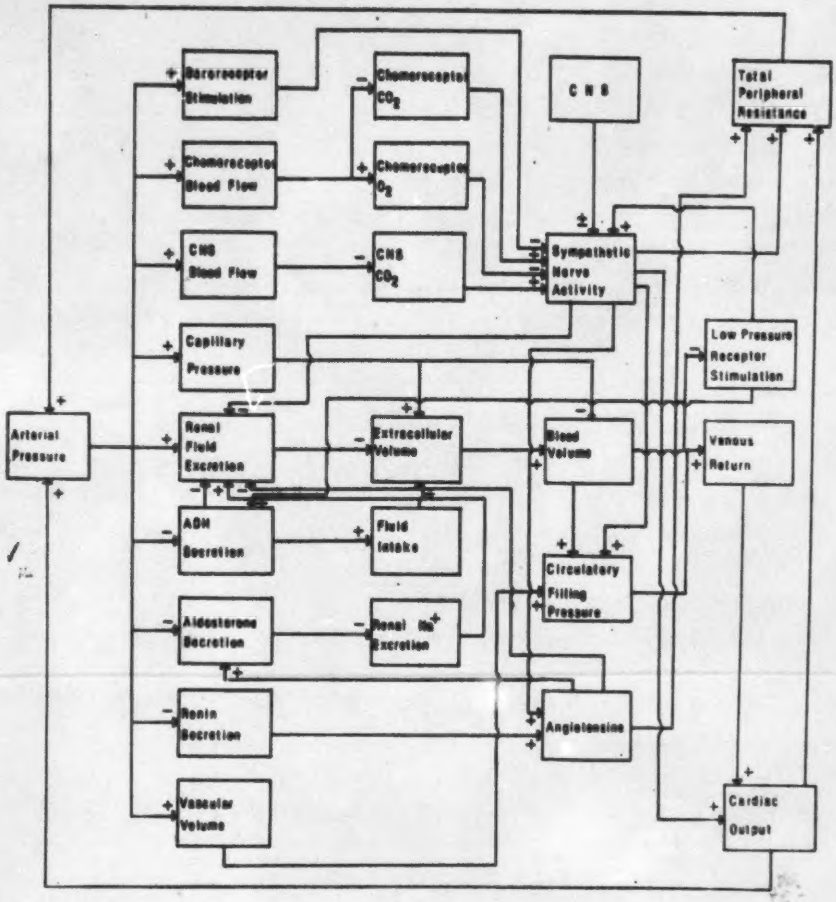
figuur 2

2 Computer models of the cardiovascular system

Modelling and simulation of the cardiovascular system has a relatively long history. Early modelling techniques included hydraulic and electrical models. Noordergraaf (1969) has reviewed the early mathematical descriptions of pressure and flow relationships in the major arteries of the body. These models were all limited to small segments of the overall cardiovascular system in view of the lack of computing techniques to solve these early models.
With the introduction of analogue computers several decades ago it became possible to describe the cardiovascular system using more complex mathematical models. Especially the work

of Beneken and co-workers (1967) represents an early milestone in the mathematical analysis of the cardiovascular system. The analogue computing methods implied a special emphasis of the description of the cardiovascular system in its electrical analogue, in which electric current represented blood flow, voltage corresponded with pressure and electrical resistance with hydraulic resistance. Therefore, such models are primarily aimed at an analogue description of the cardiovascular system without paying much attention to extrinsic control mechanisms. A second important analogue computer model of the cardiovascular system has been published by Guyton and Coleman (1967). These authors included the relationships between the circulatory system with the body fluid volumes in their model. Other analogue models of the cardiovascular system include that of Dagan and Levi (1978) and Brubakk and Aaslid's model of aorta dynamics (1978). The introduction of digital computers a number of years ago has shifted the attention of cardiovascular model building and simulation to digital programming. Such programming techniques allow a more detailed description of extrinsic control mechanisms as exemplified by the model of Boyers et al. (1972), simulating the human cardiovascular system, including nervous control and control of body fluid volumes. Other digital computer models of het cardiovascular system include the artery pressure-flow relationship model by Weygandt et al. (1978), the model of the control of cardiac output by Coleman et al. (1974), Rupeiks's (1972) model of the heart and the model of the systemic circulation and kidney by Dickinson and co-workers (1971). A major milestone in digital computer models of the cardiovascular system has been the model of integrative cardiovascular control by Guyton and co-workers (1972). This model contains detailed representations of the heart and vascular system, the kidney and body fluid volumes as well as a number of autoregulatory, neural and endocrine mechanisms that control the cardiovascular system. Figure 3 gives a schematic representation of the different elements integrated in the

model.



figuur 3

In its core it represents circulatory dynamics calculating volumes, flows, pressures, resistances and compliances of several segments of the circulatory system. Furthermore, capillary membrane dynamics and the volumes and pressures of different tissue fluids are calculated. Finally, the model contains representations of important control mechanisms, such as muscle and non-muscle autoregulatory control of blood flow, the autonomic nervous system, the renin-angiotensin system, aldosteron, antidiuretic hormone, kidney dynamics, heart hypertrophy and deterioration and the control of blood viscosity. The model is a large non-linear set of ordinary differential equations with time as the independent variable.

This model has proved to be a useful tool in the study of basic hemodynamics as well as the pathophysiology and therapy of several cardiovascular diseases (Guyton et al., 1972, 1974; Sagawa, 1975; Struyker-Boudier, 1979; Struyker-Boudier and Rahn, 1979). Some applications of this model will be presented below.

A clear problem in digital computer simulations of the cardiovascular system is the solution stability. Models of the cardiovascular system may contain integration steps differing extremely with respect to time constants. Autonomic nervous effects may act within seconds, whereas cardiac hypertrophy is a process with a time constant in the order of months. The discreteness of digital solutions of differential equations may slow solution speed tremendously or hamper the stability of the model. Coleman and co-workers (1977) have recently discussed methods to improve solution stability.

In summarizing the present state of the art of computer modelling of the cardiovascular system, we may conclude that there is a relatively wide interest in modelling segments of the cardiovascular system, such as the heart, aorta, capillaries and veins. Moreover, a few attempts have been made to build more integrative types of computer models of the cardiovascular system.

3 How to build a computer model and simulation of the cardiovascular system

In building a computer model of the cardiovascular system and the subsequent running of simulations of normal or abnormal conditions, several steps can be distinguished:

1 The model builder has to develop a clear view of the anatomical and physiological properties of the system or process he intends to model.

2 He has to formulate the quantitative relationships between the different elements to be contained in the model. This may be achieved by constructing a block-diagram showing the relationships.

3 He has to transform the relationships obtained in the previous step into unambiguous mathematical equations in which the dependent and independent variables are clearly defined as well as the quantitative relationships between these variables.

4 He has to translate the mathematical relationships into a computer language suited for the computer and operating system in which he wants to exercise the model by running simulations.

5 He has to verify the model by comparing the results of a number of simulations with data obtained from biological experiments. This step implies continuous iterative process of adapting the model to new experimental data, checking the improved model, performing experiments suggested by simulations using the model etc. Only if this step is reached does the model act as a truly important research tool.

These steps can be illustrated by discussing the construction of a relatively simple model of the hemodynamics in the aorta. Figure 4 contains a schematic representation of the arterial system as a "wind-kessel" (Frank, 1899). In this conception the aorta is considered as an elastic reservoir with a compliance C_{ao} equal to the change in volume (dV) produced by a unit change in pressure (dP).

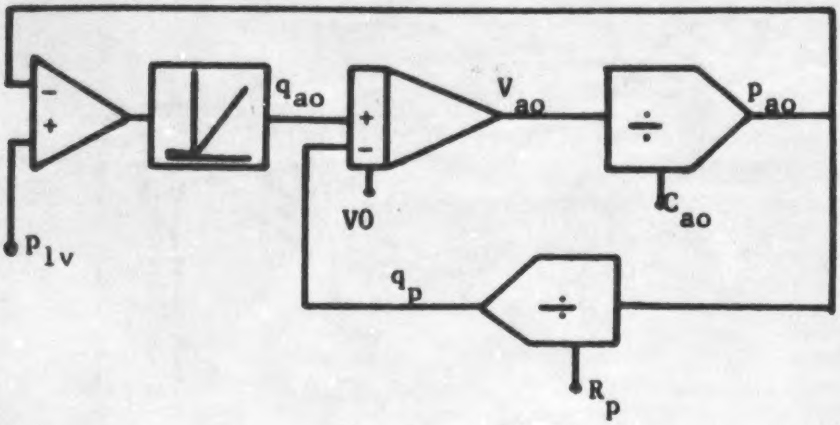


figure 4

The heart pumps a certain amount of blood per unit of time (Q_{ao}) into the aorta, whereas an amount (Q_p) leaves the aorta per unit of time. The volume of blood contained in the aorta at each moment (V_{ao}) is the integral of the inflow minus the outflow.

The next step in the process of building the model of the aorta hemodynamics is to recognize the relationships between the different elements contained in the model. This is illustrated in figure 5.

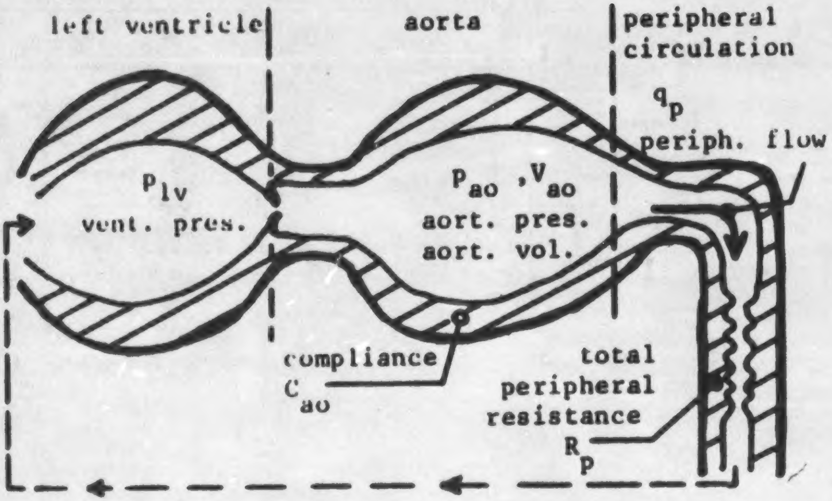


figure 5

The following step is the quantification of each step into an unambiguous mathematical relationship. The equations for the model in figures 4 and 5 would be:

$$P_{ao} = \frac{1}{C_{ao}} \int_{o}^{t=T} \left((Q_{ao} - Q_P)dt + V_{ao}(t=0) \right) \qquad (1)$$

$$Q_{ao} = f\ (P_{lv} - P_{ao}) \qquad (2)$$

$$Q_P = P_{ao} / R_P \qquad (3)$$

in which R_P is the total peripheral resistance, P_{ao} the aortic pressure and P_{lv} the left ventricle pressure.

The fourth step is to transform these mathematical relationships into a proper computer language. If the simulation language THTSIM (Technische Hogeschool Twente, Meerman, 1977) were to be used, the program would read:

```
                    STRUCTURE

: 1, TIM                      : 7, FNC, 6, 3
: 2, GAI, 1                   : 8, SUM, 7, -11
: 3, SIN, 2                   : 9, INT, 8
: 4, GAI, 3                   :10, ATT, 9
: 5, LIM, 4                   :11, ATT, 10
: 6, SUM, 5, -10

                    PARAMETERS

: 2, 6.28                     N,X,Y: 2, 0, 0
: 4, 120                      N,X.Y: 3, 10, 330
: 5, 0, 200                   : 9, 80
: 7                           :10, 1.1
N,X,Y: 1, -10, 0              :11, 1.25
```

A FORTRAN listing of the same program would read:

```
C START MODEL:
C PARAMETERS
VAO = 80.0
```

```
      CAO = 1.1                     DT = 0.01
      RP  = 1.25                    TMAX = 4.0
      PLVMAX = 120.0                T = 0.0
      W = 6.28

C     MODEL

      100 PLV = PLVMAX * SIN (W*T)
          IF (VD.LE.O) VD = 0.0
          PG = PLV-PAO
          QAO = FUNC (PG)
          QP = PAO/RP
          VAO = VAO + (QAO-QP) * DT
          PAO = VAO/CAO
          IF (T.GE.TMAX) GOTO...
          T = T + DT
          GOTO 100
          END
          FUNCTION FUNC (PG)
          IF (PG.LE.O.O) FUNC = 0.0
          IF (PG.GT.O.O) FUNC = 33.0 * PG
          RETURN
          END
```

The advantage of using a typical simulation language like THTSIM is that the computer language takes care of an important part of the programming. However, simulation languages are less flexible with respect to the possibilities of programming as is discussed in more detail elsewhere in this volume (Min and Struyker Boudier, 1979).

Finally, the model is run on the computer. Figure 6 gives the results of 2 simulations of 2 seconds each. One simulation shows the pressure curve in the aorta under normal conditions and the other the curve if the aortic compliance is reduced to 20% of its normal value. The latter case is, in fact, a simulation of an arteriosclerotic artery.

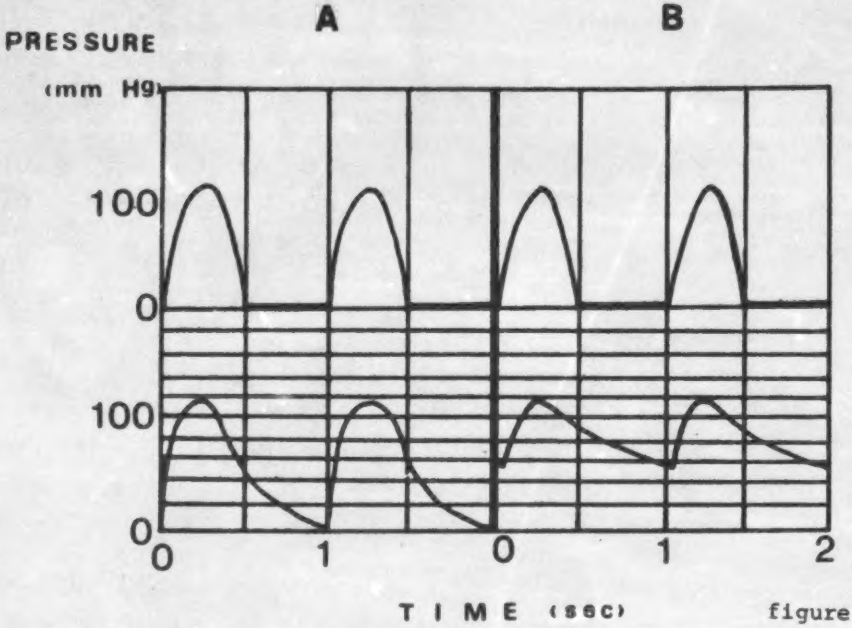


figure 6

A cardiovascular physiologist upon inspection of the pressure curve given in figure 5 would immediately conclude that the curve lacks the typical dicrotic notch-present in the descending part of a human aortic pressure curve. The dicrotic notch in vivo is caused by the backflow of blood into the aorta after closure of the aortic valves. This phenomenon was not considered with the construction of the original model and could therefore impossibly show up in the simulation. This illustrates the necessity of constantly comparing simulated results with data obtained from biological experiments.

4 Application of computer models and simulations of the cardiovascular system

We have discussed so far the history of cardiovascular computer

modelling as well as the strategies involved in building such models. This final paragraph is devoted to a brief survey of the major applications of cardiovascular computer models.
It was discussed previously already that the original analogue computer models of the cardiovascular system were aimed primarily at an accurate description of the structure of the cardiovascular system and its hemodynamic principles. These models were used to simulate, e.g. the relationship between pressure and flow in different parts of the circulatory system, the pressure-volume relationship in the heart or veins or the capillary exchange of fluids and nutrients.
The introduction of larger models aimed at a more integrated approach to cardiovascular control by Beneken and co-workers (1967), Boyers et al. (1972) and Guyton and co-workers (1967, 1972) allowed a more comprehensive view. The model of Beneken and de Wit (1967) primarily described the pumping characteristics of the heart. Boyers et al. (1972) used their model to simulate the cardiovascular events following a change of posture, blood loss and transfusion, as well as the effects of drugs blocking the autonomic nervous system. The most versatile model, however, has been the previously discussed model of overall circulatory control published by Guyton and co-workers (1972). This model has been tested against the real systems behavior in a large number of situations of physiological or pathophysiological changes of systems parameters. Guyton and co-workers (1972) have described simulations of among other things different forms of hypertension, congestive heart failure, nephrosis and muscular exercise. In each of these cases the computer model served as a rigorous tool to test the validity of hypotheses concerning these disease states or changes of systems parameters. Others have used this model to simulate body fluid control (Ruigt and Woerlee, 1978). We have recently described still other applications, viz. simulation of sympathetic nervous control of the circulatory system (Struyker Boudier and Rahn, 1979) and simulation of the

cardiovascular effects of antihypertensive drugs (Struyker-Boudier, 1979). The reader is referred to these original articles for a detailed discussion of these applications.

The computer model of the circulatory system by Guyton and co-workers has proved to be an extremely useful tool in cardiovascular research. Already it has provoked intensive discussions and new research in the fields of basic hemodynamics, kidney function and the pathophysiology and treatment of hypertensive disease. The results of these discussions and new research will undoubtedly force adaptations in the model to explain new -experimentally based- insights.

However, this process shows exactly the particular strenght of computer models and simulations of biological systems and processes: they provide a rigorous tool for the quantitative tests of hypotheses or theories.

Legends to the figures

Figure 1	Schematic representation of the anatomy of the cardiovascular system.
Figure 2	Block-diagram showing the relationships between the primary mechanisms involved in cardiovascular control (After Guyton et al., 1974).
Figure 3	Elements contained in the model of overall cardiovascular control by Guyton and co-workers (1972).
Figure 4	Schematic representation of the aorta "windkessel".
Figure 5	Analogue diagram of the aorta "windkessel" model.
Figure 6	Computer simulation of the aortic pressure curve (lower part) as a function of a given ventricular pressure curve (upper part) during normal conditions (b) as well as after reducing the aortic compliance to 20% of its normal value (A). The horizontal axis represents time in seconds, the vertical one pressure in mm Hg.

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